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Different Diet Types and Their Association with Depression in Adults

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ABSTRACT

Depression is a significant global public health concern that is shaped by a complex interaction of biological, psychological, social, and lifestyle-related factors. Among these lifestyle factors, diet has attracted growing scientific interest due to its potential influence on mental health and depressive symptoms. This thesis explores the relationship between dietary patterns and depression, with particular focus on the Mediterranean diet, Western dietary patterns, and plant-based diets.

This literature-based thesis reviews and synthesizes evidence from observational studies, systematic reviews, meta-analyses, and dietary intervention trials. It examines the key characteristics of these dietary patterns, evaluates their reported associations with depression, and discusses the biological mechanisms that may help explain these relationships.

The available evidence indicates that stronger adherence to the Mediterranean diet is generally linked to more favorable depression-related outcomes. These associations may be attributed to the combined influence of multiple dietary components that affect inflammation, oxidative stress, metabolic function, gut–brain communication, and other biological processes relevant to mental health. In contrast, Western dietary patterns are more frequently associated with higher levels of depressive symptoms, although these relationships are also affected by a range of lifestyle, behavioral, and socioeconomic factors. Evidence regarding plant-based diets remains less consistent, suggesting that overall dietary quality and nutritional adequacy may be more important than simply adhering to or excluding a particular dietary category.

Overall, the current literature suggests that diet quality may represent an important factor in mental health. Nevertheless, diet should not be viewed as an independent cause or determinant of depression. Further well-designed longitudinal studies and dietary intervention trials are needed to strengthen the evidence base and provide a clearer understanding of the relationship between dietary patterns and depression.

CHAPTER 1

INTRODUCTION

1.1 Depression as a Global Health Issue

Depression is currently recognized as one of the leading contributors to disability and disease burden worldwide. According to the World Health Organization (WHO), depression is a common mental disorder characterized by persistent sadness, loss of interest or pleasure in activities, fatigue, sleep disturbances, impaired concentration, feelings of worthlessness, changes in appetite, and alterations in cognitive functioning (WHO, 2025 *Depressive Disorder (Depression)*). Unlike temporary emotional distress, depression may become chronic or recurrent and can significantly impair an individual's social, occupational, and interpersonal functioning (Parletta et al., 2019).

The public health significance of depression is related to both its high prevalence and its long-term consequences. The WHO estimates that millions of individuals worldwide experience depressive symptoms, making depression one of the leading contributors to years lived with disability globally (WHO, 2025 *Depressive Disorder (Depression)*). Depression also imposes a substantial economic burden through reduced productivity, increased healthcare utilization, absenteeism, and early retirement (Greenberg et al., 2021). In severe cases, depression may lead to suicidal behavior, further increasing its social and medical impact (WHO, 2025 *Depressive Disorder (Depression)*).

Depression can manifest differently across age groups (Fiske et al., 2009; Korczak et al., 2023). In adolescents, depressive symptoms are often associated with irritability, social withdrawal, academic difficulties, sleep disturbances, and changes in interpersonal relationships (Korczak et al., 2023). This age group is particularly vulnerable to risk factors such as bullying, family conflict, trauma, social pressure, and stressful school environments (Korczak et al., 2023; Thapar et al., 2012). Young adults may experience depressive symptoms related to major life transitions, including entry into higher education, employment instability, financial pressures, relationship difficulties, and increasing independence (Arnett et al., 2014; Auerbach et al., 2016). Studies also suggest that depressive symptoms emerging during late adolescence may persist in young adulthood, making this developmental period particularly important for early identification and prevention efforts (Keyes et al., 2024). Among older adults, depression may be more difficult to recognize because symptoms often present as somatic complaints, cognitive changes, reduced interest in daily activities, fatigue, or functional decline, rather than solely as persistent sadness

(Fiske et al., 2009). Older adults may also be at greater risk when depression coexists with chronic illness, social isolation, disability, or limited access to healthcare services (WHO, *Depressive Disorder (Depression)*; Fiske et al., 2009).

Initially, psychiatric research focused primarily on neurotransmitter abnormalities and psychological explanations of depression (Belmaker & Agam, 2008; Lopresti et al., 2013). However, more recent evidence suggests that depression is also closely associated with systemic physiological dysfunction (Berk et al., 2013; Marx et al., 2021). Consequently, increasing attention has been directed towards understanding biological mechanisms such as inflammation, oxidative stress, mitochondrial dysfunction, gut dysbiosis, and metabolic abnormalities (Berk et al., 2013; Marx et al., 2021; Miller & Raison, 2016). This perspective supports the view that depression should not be regarded solely as a psychological or mood-related disorder, but rather as a complex systemic condition involving interactions between the brain and multiple physiological systems (Berk et al., 2013; Marx et al., 2021). A growing body of evidence indicates a significant relationship between depression and chronic physical diseases (Lopresti et al., 2013; Marx et al., 2021). Depression frequently co-occurs with obesity, type 2 diabetes, metabolic syndrome, chronic inflammation, insomnia, and cardiovascular disease (Lopresti et al., 2013). This relationship appears to be bidirectional (Lopresti et al., 2013; Marx et al., 2021). Chronic physical conditions may increase the risk of depressive symptoms through mechanisms such as inflammation, reduced quality of life, and psychological distress (Lopresti et al., 2013; Miller & Raison, 2016). Conversely, depression may negatively influence lifestyle behaviors, metabolic health, and inflammatory regulation, thereby contributing to the development or progression of physical illness (Lopresti et al., 2013).

There is growing interest in understanding the modifiable risk factors associated with depression (Firth et al., 2020). Although genetic predisposition and adverse life events remain important determinants of mental health, increasing attention has been directed towards lifestyle factors that may significantly influence the onset, progression, and management of depressive symptoms (Firth et al., 2020; Merlo & Sugden, 2025). Consequently, a broader perspective has emerged that examines how behaviors such as diet, physical activity, sleep, smoking, alcohol consumption, and stress management may contribute to the prevention and management of mental disorders (Merlo & Sugden, 2025).

Traditional treatments for depression include psychotherapy and pharmacological interventions (WHO 2025, *Depressive Disorder (Depression)*). Both approaches have demonstrated effectiveness for many individuals (WHO 2025, *Depressive Disorder (Depression)*). However, treatment response remains heterogeneous, and relapse rates continue to be substantial (Firth et al., 2020). Furthermore, access to mental healthcare remains inadequate in many parts of the world. WHO reports that many individuals experiencing depressive symptoms, particularly in low- and middle-income countries, do not receive appropriate treatment (WHO 2025, *Depressive Disorder (Depression)*). These limitations have increased interest in preventive strategies and supportive interventions targeting modifiable risk factors (Firth et al., 2020; Merlo & Sugden, 2025) . This perspective does not imply that depression can be explained solely by unhealthy lifestyle behaviors, as such an interpretation would overlook the complexity of the disorder and the multiple factors that contribute to its development (Firth et al., 2020; Marx et al., 2021). Rather, lifestyle factors are increasingly viewed as one component of a broader biopsychosocial framework, in which biological, psychological, and social influences interact to shape mental health outcomes (Firth et al., 2020).

Among modifiable risk factors, diet has gained increasing attention within the field of lifestyle psychiatry, as a growing body of evidence suggests that dietary quality may influence mental health outcomes and depressive symptoms (Firth et al., 2020; Lassale et al., 2019; Marx et al., 2017).

Overall, depression is considered a complex and multifactorial disorder influenced by interactions among biological, behavioral, environmental, physiological, and social factors (Berk et al., 2013; Firth et al., 2020; Marx et al., 2021). Since several lifestyle-related factors are potentially modifiable, increasing attention has been directed toward understanding their role in mental health outcomes (Firth et al., 2020).

1.2 Lifestyle and Mental Health

Lifestyle factors play an important role in both physical and mental health and are increasingly recognized as contributors to mental health outcomes, including depressive symptoms (Firth et al., 2020). In recent years, researchers have increasingly examined how daily behaviors such as physical activity, sleep, smoking, stress management, social interactions, and dietary habits influence mental health (Firth et al., 2020).

Lifestyle psychiatry, an emerging field of research and clinical practice, investigates how modifiable lifestyle behaviors may contribute to the prevention and management of mental disorders (Merlo & Sugden, 2025). This approach acknowledges the importance of both internal factors, such as trauma and emotion regulation, and external factors, including physical activity, sleep, stress, and diet (Merlo & Sugden, 2025). One of the main reasons lifestyle behaviors have attracted considerable attention is that they are potentially modifiable (Firth et al., 2020). Although genetic predisposition and adverse life experiences remain important determinants of depression risk, lifestyle factors may represent valuable targets for preventive and therapeutic interventions aimed at improving mental health outcomes (Firth et al., 2020; Remes et al., 2021). At the same time, researchers emphasize that depression cannot be explained solely by unhealthy lifestyle behaviors or personal choices (Berk et al., 2013; Marx et al., 2021). Depression itself may negatively affect motivation, appetite, sleep quality, concentration, and self-care behaviors (Lopresti et al., 2013; Molendijk et al., 2018). Consequently, the relationship between lifestyle factors and depression is widely considered to be bidirectional, with each influencing the other over time (Firth et al., 2020).

Physical activity is one of the most extensively studied lifestyle factors associated with depression (Schuch et al., 2018). A meta-analysis conducted by Schuch et al. (2018) reported that individuals with higher levels of physical activity had a lower risk of developing depression over time. Similar findings were reported by Kandola et al. (2019) who identified exercise as a potential protective factor against depressive disorders. Several mechanisms have been proposed to explain these associations, including enhanced neuroplasticity, increased endorphin release, reduced inflammation, improved sleep quality, more effective stress regulation, and better metabolic health (Kandola et al., 2019). Furthermore, several systematic reviews and meta-analyses have suggested that physical activity interventions can reduce depressive symptoms and, in some cases, may represent a useful supportive intervention in the management of depression (Conn, 2010; Rimer et al., 2012). Despite these promising findings, evidence regarding the long-term effectiveness of physical activity as a treatment for depression remains limited (Krogh et al., 2011).

Sleep is another key lifestyle factor potentially related to mental health outcome. Sleep disturbance is one of the most common symptoms of depression and can include insomnia, hypersomnia, fragmented sleep, early awake or impaired circadian cycle rhythms (Nutt et al., 2008). Sleep disturbances are associated to a higher risk of depression in the future (Baglioni et al., 2011). Also

short and long hours of sleep are associated to a higher risk of experiencing depressive symptoms (Zhai et al., 2015).

Disturbed sleep can negatively affect inflammatory activity, cortisol regulation, function of neurotransmitters, oxidative stress and neuroplasticity (Lopresti et al., 2013). Furthermore, chronic insomnia has also been associated with a poorer response to treatments and also an increased risk of a comeback (Lopresti et al., 2013).

Smoking has also been associated with mental health disorders, including depression (Fluharty et al., 2017). The prevalence of smoking is higher among individuals experiencing depression than in the general population (Fluharty et al., 2017). Several studies suggest that depressive symptoms may increase the likelihood of initiating or maintaining smoking behaviors, however it remains unclear whether smoking contributes to the development of depression, whether depression increases the risk of smoking, or whether the relationship is bidirectional (Fluharty et al., 2017).

Chronic and excessive alcohol consumption has been linked to impaired emotional regulation, sleep disturbances, and increased severity of depressive symptoms (McHugh & Weiss, 2019). Researchers have consistently reported a high degree of co-occurrence between problematic alcohol use and depression, suggesting a complex and potentially bidirectional relationship between these conditions (McHugh & Weiss, 2019).

Stress is another important lifestyle-related factor that may influence depression risk. Chronic stress can activate the hypothalamic–pituitary–adrenal (HPA) axis, resulting in increased secretion of cortisol. Persistent activation of the HPA axis has been associated with inflammation, impaired neuroplasticity, sleep disturbances, alterations in appetite, and an increased risk of depressive symptoms (Marx et al., 2021).

Usually all the lifestyle factors, low physical activity, smoking, alcohol, stress, diet quality, cluster all together and the effect of this cluster is important in researches on depression, because unhealthy pattern may interact and affect common biological pathways, like inflammation, oxidative stress, vascular dysfunction and altered composition of gut microbiota (Firth et al., 2020; Marx et al., 2021).

Within this broader lifestyle framework, dietary patterns have received increasing attention within the fields of lifestyle psychiatry and mental health research due to their potential influence on several biological pathways involved in depression (Firth et al., 2020; Marx et al., 2017, 2021). A growing body of epidemiological evidence suggests that dietary patterns and overall diet quality

may be associated with mental health outcomes (Marx et al., 2017; Molendijk et al., 2018), highlighting the importance of further examining the relationship between diet and depression.

1.3 Diet and Mental Health

As discussed previously, the relationship between diet and mental health has received increasing attention in psychiatric and public health research over recent decades (Marx et al., 2017). Emerging evidence suggests that, alongside genetic predisposition and psychological factors, diet quality may play an important role in shaping mental health outcomes, particularly those related to depression (Marx et al., 2017)

The growing body of evidence in this area has contributed to the development of nutritional psychiatry, an emerging field that examines how nutrients, dietary patterns, and eating behaviors influence mental health and psychiatric disorders (Marx et al., 2017; Sarris et al., 2015).

Optimal brain function requires an adequate intake of amino acids, fatty acids, vitamins, and minerals, which are involved in neurotransmitter synthesis, neuronal signaling, and neuroplasticity (Lopresti et al., 2013; Sarris et al., 2015). Consequently, researchers have investigated a range of nutrients because of their potential roles in neurotransmitter metabolism and neuronal function (Sarris et al., 2015).

However, increasing attention has been drawn to the limitations of studying individual nutrients in isolation (Marx et al., 2017). Human diets are inherently complex, and nutrients interact biologically when consumed as part of whole foods and dietary patterns (Lopresti et al., 2013; Marx et al., 2017). For this reason, nutritional psychiatry has gradually shifted from a focus on single nutrients towards the investigation of overall dietary patterns and diet quality (Lai et al., 2014; Quirk et al., 2013).

Among the dietary patterns commonly investigated in relation to depression are the Mediterranean diet, the Western dietary pattern, and plant-based dietary patterns (Jain et al., 2022; Lai et al., 2014; Quirk et al., 2013). The Mediterranean diet is characterized by a high intake of vegetables, fruits, legumes, olive oil, whole grains, and fish (Sánchez-Villegas et al., 2009), whereas the Western dietary pattern is typically characterized by a high consumption of refined carbohydrates, ultra-processed foods, saturated fats, and added sugars (Jacka et al., 2010).

Plant-based dietary patterns have also attracted increasing attention within nutritional psychiatry, although findings remain inconsistent and appear to depend on factors such as overall diet quality, nutritional adequacy, and the specific types of foods consumed (Jain et al., 2022).

Current evidence generally suggests that healthier dietary patterns, particularly those rich in minimally processed foods, may be associated with a lower risk of depressive symptoms compared with dietary patterns characterized by a high intake of ultra-processed foods and lower nutritional quality (Lai et al., 2014; Li et al., 2017).

However, researchers continue to emphasize important methodological limitations within this field, including the predominance of observational study designs, reliance on self-reported dietary assessment methods, and the possibility of reverse causality (Lassale et al., 2019; Molendijk et al., 2018). This is particularly relevant because depression itself may negatively influence eating behaviors and dietary choices, making it difficult to determine the direction of the observed associations (Lassale et al., 2019; Molendijk et al., 2018).

Although current findings do not establish a definitive causal relationship, growing evidence continues to support the importance of investigating diet quality as a potential factor involved in mental health and depressive disorders (Lassale et al., 2019; Marx et al., 2017; Molendijk et al., 2018).

1.4 Biological Mechanisms Linking Diet and Depression

Inflammation is one of the most extensively investigated biological mechanisms associated with depression (Berk et al., 2013; Miller & Raison, 2016). Although depression has traditionally been understood primarily as a disorder of neurotransmitter imbalance, growing evidence suggests that immune system dysregulation and chronic low-grade inflammation may also contribute to the development and progression of depressive symptoms (Berk et al., 2013; Miller & Raison, 2016). This perspective has led researchers to propose the inflammatory hypothesis of depression, which suggests that inflammatory processes may influence several biological pathways involved in mood regulation and emotional functioning (Felger & Lotrich, 2013; Miller & Raison, 2016).

Numerous studies have reported elevated concentrations of inflammatory biomarkers among individuals with depressive disorders (Haapakoski et al., 2015; Osimo et al., 2020). Among the most frequently investigated biomarkers are C-reactive protein (CRP), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF-α) (Felger & Lotrich, 2013; Miller & Raison, 2016). Meta-

analytic evidence has demonstrated that individuals with depression often exhibit higher levels of these inflammatory markers than non-depressed individuals, supporting a potential association between immune activation and depressive symptomatology (Haapakoski et al., 2015; Osimo et al., 2020).

Inflammatory cytokines may influence brain function through several biological pathways (Felger & Lotrich, 2013; Miller & Raison, 2016). One proposed mechanism involves interactions between inflammatory mediators and neurotransmitter systems involved in mood regulation (Felger & Lotrich, 2013; Miller & Raison, 2016). Elevated levels of pro-inflammatory cytokines may alter the synthesis, release, and reuptake of neurotransmitters, including serotonin, dopamine, and norepinephrine, thereby potentially contributing to the development of depressive symptoms (Felger & Lotrich, 2013; Miller & Raison, 2016).

A particularly important pathway involves the activation of the enzyme indoleamine 2,3-dioxygenase (IDO) (Arnone et al., 2018; Felger & Lotrich, 2013). Under conditions of increased inflammatory activity, cytokines such as IL-6, TNF-α, and interferon-γ may stimulate IDO activity, redirecting tryptophan metabolism away from serotonin synthesis and towards the kynurenine pathway (Arnone et al., 2018; Felger & Lotrich, 2013). This process results in increased production of kynurenine metabolites, some of which may exert neurotoxic effects and contribute to neuroinflammation, neuronal dysfunction, and depressive symptomatology (Arnone et al., 2018).

Inflammation may also affect neuroendocrine regulation and stress-response systems (Berk et al., 2013; Miller & Raison, 2016). Chronic inflammatory activity has been associated with alterations in hypothalamic–pituitary–adrenal (HPA) axis function and cortisol regulation, both of which are frequently implicated in the pathophysiology of depression (Berk et al., 2013; Miller & Raison, 2016).

Although elevated inflammatory markers are not observed in all individuals with depression, substantial evidence supports the existence of an inflammatory subtype of depression in at least a subset of affected individuals (Miller & Raison, 2016; Osimo et al., 2020).

Researchers increasingly propose that inflammation should not be viewed as an isolated process but rather as one component of a broader network of interconnected biological mechanisms, including oxidative stress, metabolic dysfunction, alterations in gut microbiota composition, and impaired neuroplasticity (Berk et al., 2013; Marx et al., 2021).

Despite the growing evidence supporting the role of inflammation in depression, the direction of this relationship remains complex (Miller & Raison, 2016). Depression itself may contribute to increased inflammatory activity through both behavioral and physiological pathways, including chronic stress, sleep disturbances, and unhealthy lifestyle behaviors (Miller & Raison, 2016).

Oxidative stress represents another important biological mechanism that has increasingly been implicated in the pathophysiology of depression (Berk et al., 2013; Correia et al., 2023). Oxidative stress occurs when the production of reactive oxygen species (ROS) exceeds the capacity of endogenous antioxidant defense systems, resulting in an imbalance that may contribute to cellular and molecular damage (Correia et al., 2023)

Although ROS are naturally produced during normal cellular metabolism and perform important physiological functions, their excessive accumulation may damage proteins, lipids, and DNA, ultimately impairing cellular function and viability (Correia et al., 2023).

The brain is considered particularly vulnerable to oxidative damage because of its high oxygen consumption, abundant lipid content, and relatively limited antioxidant defense capacity compared with other tissues (Lopresti et al., 2013). Consequently, prolonged oxidative stress may contribute to neuronal dysfunction and structural alterations in brain regions involved in mood regulation and emotional processing (Lopresti et al., 2013; Marx et al., 2021).

Growing evidence suggests that oxidative stress may play an important role in the pathophysiology of depression (Correia et al., 2023). Several studies have reported elevated levels of oxidative damage markers, together with reduced antioxidant capacity, among individuals with depressive disorders (Correia et al., 2023).

Oxidative stress and inflammation are closely interconnected biological processes (Berk et al., 2013; Correia et al., 2023). Pro-inflammatory cytokines may increase the production of reactive oxygen species (ROS), whereas oxidative damage may further stimulate inflammatory responses, creating a self-perpetuating cycle that contributes to cellular dysfunction and disease progression (Berk et al., 2013; Correia et al., 2023).

Despite substantial evidence supporting an association between oxidative stress and depression, it remains difficult to determine whether oxidative abnormalities represent a cause, a consequence, or a contributing factor in the development of depressive disorders (Correia et al., 2023). Nevertheless, current evidence suggests that oxidative stress constitutes an important component of the biological mechanisms underlying depression (Correia et al., 2023).

The gut-brain axis has emerged as one of the most rapidly expanding areas of research within nutritional psychiatry (Berding et al., 2021; Zhu et al., 2022). It refers to a bidirectional communication network connecting the gastrointestinal tract and the central nervous system through neural, endocrine, immune, and metabolic pathways (Zhu et al., 2022).

The human gastrointestinal tract harbors trillions of microorganisms collectively known as the gut microbiota (Berding et al., 2021; Dash et al., 2015). These microbial communities contribute to a wide range of physiological functions, including nutrient metabolism, immune regulation, maintenance of intestinal barrier integrity, and the production of bioactive compounds that may influence brain function and behavior (Berding et al., 2021; Dash et al., 2015).

Researchers increasingly suggest that alterations in gut microbiota composition may influence emotional regulation and mental health outcomes (Berding et al., 2021; Cheung et al., 2019). Several studies have reported differences in microbial composition between individuals with depression and healthy controls; however, findings remain heterogeneous, and the direction of causality remains uncertain (Cheung et al., 2019).

One proposed mechanism involves short-chain fatty acids (SCFAs), including acetate, propionate, and butyrate, which are produced through the bacterial fermentation of dietary fiber (Berding et al., 2021; Zhu et al., 2022). SCFAs contribute to the maintenance of intestinal barrier integrity, immune regulation, and communication between the gastrointestinal tract and the brain (Berding et al., 2021; Zhu et al., 2022).

Another proposed mechanism involves intestinal permeability (Zhu et al., 2022). Disruption of the intestinal barrier may facilitate the translocation of bacterial products into the systemic circulation, thereby promoting inflammatory activity and potentially affecting central nervous system function (Zhu et al., 2022).

Gut microbiota may also influence neurotransmitter metabolism (Berding et al., 2021; Zhu et al., 2022). Certain bacterial species participate in metabolic pathways related to serotonin, dopamine, gamma-aminobutyric acid (GABA), and tryptophan metabolism, suggesting potential interactions between gut microbial communities and the regulation of mood and behavior (Zhu et al., 2022).

Although this area remains under active investigation, current evidence supports the role of the gut microbiota as an important component of the interconnected biological network associated with depression (Berding et al., 2021; Cheung et al., 2019; Zhu et al., 2022).

Neurotransmitters are chemical messengers that facilitate communication between neurons and play fundamental roles in mood regulation, cognition, motivation, and emotional behavior (Sarris et al., 2015). Several neurotransmitter systems have been implicated in the pathophysiology of depression, particularly those involving serotonin, dopamine, norepinephrine, and gamma-aminobutyric acid (GABA) (Sarris et al., 2015).

The monoamine hypothesis of depression historically proposed that reduced availability of serotonin, norepinephrine, and dopamine contributes to the development of depressive symptoms (Berk et al., 2013). Although this hypothesis remains influential, researchers increasingly recognize that depression involves a complex interplay of biological processes extending beyond neurotransmitter imbalance alone (Berk et al., 2013; Marx et al., 2021).

Serotonin has received particular attention because of its involvement in mood regulation, appetite, sleep and emotional processing (Sarris et al., 2015). Serotonin synthesis depends on the availability of tryptophan, an essential amino acid obtained through diet (Sarris et al., 2015). Alterations in tryptophan metabolism, particularly through activation of the kynurenine pathway during inflammatory states, may reduce serotonin availability and contribute to depressive symptoms (Arnone et al., 2018).

Dopamine is primarily involved in reward processing, motivation and pleasure, functions that are often impaired in depression (Berk et al., 2013; Sarris et al., 2015). Norepinephrine contributes to attention, arousal and stress-response regulation, while GABA serves as the major inhibitory neurotransmitter in the central nervous system and is involved in emotional regulation and anxiety control (Sarris et al., 2015).

Several vitamins and minerals serve as essential cofactors in neurotransmitter synthesis and metabolism, including folate, vitamin B12, vitamin B6, zinc, magnesium, and iron (Lopresti et al., 2013; Sarris et al., 2015). Consequently, researchers have increasingly investigated the potential relationships among nutritional status, neurotransmitter function, and mental health outcomes (Lopresti et al., 2013; Sarris et al., 2015).

Neuroplasticity refers to the brain's ability to adapt, reorganize, and modify neural connections in response to internal and external stimuli (Rădulescu et al., 2021). This process is fundamental to learning, memory formation, emotional regulation, and adaptation to environmental changes (Rădulescu et al., 2021).

Evidence suggests that depression is associated with structural and functional alterations in brain regions involved in emotional regulation, particularly the hippocampus, prefrontal cortex, and amygdala (Duman et al., 2016; Rădulescu et al., 2021). Studies investigating stress and depression suggest that impaired synaptic plasticity, reduced neurogenesis, and alterations in neural circuitry may contribute to the development of depressive symptoms (Duman et al., 2016; Pittenger & Duman, 2008).

Chronic stress is considered one of the major factors influencing neuroplasticity (Duman et al., 2016; Pittenger & Duman, 2008). Prolonged activation of stress-response systems may negatively affect neurogenesis, synaptic plasticity, and neuronal survival, particularly within brain regions involved in mood regulation and cognitive functioning (Duman et al., 2016; Pittenger & Duman, 2008). These findings support the hypothesis that stress-induced impairments in neuroplasticity may contribute to the pathophysiology of depression (Duman et al., 2016; Rădulescu et al., 2021). Brain-derived neurotrophic factor (BDNF) has received considerable attention in this context. BDNF is a neurotrophin involved in neuronal growth, survival, and synaptic plasticity (Castrén & Monteggia, 2021). Impaired BDNF signaling has been implicated in mood disorders, although findings remain inconsistent across some studies (Castrén & Monteggia, 2021). Consequently, BDNF-related pathways are considered important for understanding both neuroplasticity in depression and the mechanisms underlying antidepressant treatment (Castrén & Monteggia, 2021; Duman et al., 2016).

Researchers increasingly suggest that neuroplasticity does not operate in isolation but rather interacts with other biological processes implicated in depression, including inflammation, oxidative stress, metabolic dysfunction, and neurotransmitter regulation (Berk et al., 2013; Marx et al., 2021). Consequently, depression may be conceptualized as a multifactorial disorder involving interconnected physiological mechanisms that influence brain structure, brain function, and emotional regulation (Marx et al., 2021; Rădulescu et al., 2021).

Metabolic dysfunction has increasingly been recognized as an important factor associated with depression (Al-Khatib et al., 2022; Lyra E Silva et al., 2019; Milaneschi et al., 2019). Obesity, insulin resistance, metabolic syndrome, and type 2 diabetes frequently co-occur with depressive disorders, suggesting the existence of potential biological links between metabolic health and mental health outcomes (Al-Khatib et al., 2022; Lyra E Silva et al., 2019; Milaneschi et al., 2019).

Several mechanisms have been proposed to explain these associations (Marx et al., 2021; Milaneschi et al., 2019). Chronic low-grade inflammation, oxidative stress, impaired insulin signaling, and neuroendocrine dysregulation are frequently discussed as shared biological pathways linking metabolic disorders and depression (Al-Khatib et al., 2022; Marx et al., 2021; Milaneschi et al., 2019). Consequently, metabolic abnormalities may contribute to depressive symptoms through mechanisms that overlap with immune, endocrine, and neurobiological processes (Lyra E Silva et al., 2019; Milaneschi et al., 2019).

Insulin resistance has attracted particular attention because insulin signaling is involved not only in glucose regulation but also in neurobiological processes, including neuronal function, cognition, and neuroplasticity (Lyra E Silva et al., 2019; Marx et al., 2021). Consequently, impaired insulin sensitivity may affect both metabolic and brain function, potentially contributing to mood disturbances and depressive symptoms (Lyra E Silva et al., 2019; Marx et al., 2021).

Another important biological system implicated in depression is the hypothalamic–pituitary–adrenal (HPA) axis, which regulates physiological responses to stress (Pariante & Lightman, 2008). Hyperactivity and dysregulation of the HPA axis have been consistently observed in major depressive disorder, with altered cortisol regulation representing one of the most robust neuroendocrine findings in this field (Pariante & Lightman, 2008)

Dysregulation of the HPA axis may interact with inflammation, metabolic dysfunction, and alterations in neurotransmitter systems, thereby contributing to the biological complexity of depressive disorders (Berk et al., 2013; Marx et al., 2021; Pariante & Lightman, 2008).

The relationship between depression and metabolic dysfunction appears to be bidirectional (Al-Khatib et al., 2022; Milaneschi et al., 2019). Metabolic disorders may increase vulnerability to depression, while depression may contribute to behavioral changes, such as reduced physical activity, disturbed sleep, and unhealthy lifestyle behaviors, that negatively affect metabolic health (Al-Khatib et al., 2022; Milaneschi et al., 2019).

Although individual biological mechanisms are often discussed separately, current evidence suggests that they function as components of a highly interconnected biological network (Berk et al., 2013; Marx et al., 2021). Inflammation, oxidative stress, alterations in gut microbiota composition, neurotransmitter metabolism, impaired neuroplasticity, metabolic dysfunction, and HPA axis dysregulation may interact and influence one another in the pathophysiology of depression (Berk et al., 2013; Marx et al., 2021; Miller & Raison, 2016).

For example, chronic inflammatory activity may activate the kynurenine pathway and influence neurotransmitter metabolism (Arnone et al., 2018; Felger & Lotrich, 2013). Inflammatory processes may also interact with intestinal barrier function, gut microbiota composition, and gut–brain axis signaling (Berding et al., 2021; Zhu et al., 2022). Similarly, oxidative stress has been linked to neuroinflammatory processes and neuronal dysfunction (Correia et al., 2023), while alterations in neurogenesis and synaptic plasticity have been implicated in depression-related neurobiological changes (Duman et al., 2016). Furthermore, metabolic dysfunction and obesity share several biological pathways with depression, including inflammatory, neuroendocrine, and metabolic mechanisms (Milaneschi et al., 2019).

Because of these interactions, depression is increasingly conceptualized as a multifactorial disorder arising from the combined influence of biological, psychological, behavioral, and environmental factors rather than the dysfunction of a single pathway (Berk et al., 2013; Marx et al., 2021). Contemporary models emphasize that multiple biological systems may contribute simultaneously to the development and progression of depressive symptoms (Berk et al., 2013; Marx et al., 2021; Miller & Raison, 2016).

Despite substantial advances in understanding these mechanisms, important limitations remain (Marx et al., 2021; Molendijk et al., 2018). Many studies investigating biological pathways are observational or experimental in nature rather than clinical, making it difficult to establish definitive causal relationships (Marx et al., 2021; Molendijk et al., 2018). Furthermore, depression itself may influence inflammation, metabolic health, sleep quality, appetite, and lifestyle behaviors, thereby complicating the interpretation of observed associations (Miller & Raison, 2016; Molendijk et al., 2018).

Nevertheless, current evidence supports the biological plausibility of a relationship between diet and depression (Marx et al., 2021; Sarris et al., 2015). Multiple interconnected pathways have been identified through which nutritional factors may influence brain function, emotional regulation, and mental health outcomes (Marx et al., 2021; Sarris et al., 2015). An overview of the proposed biological pathways linking dietary patterns and depression is presented in Figure 1.

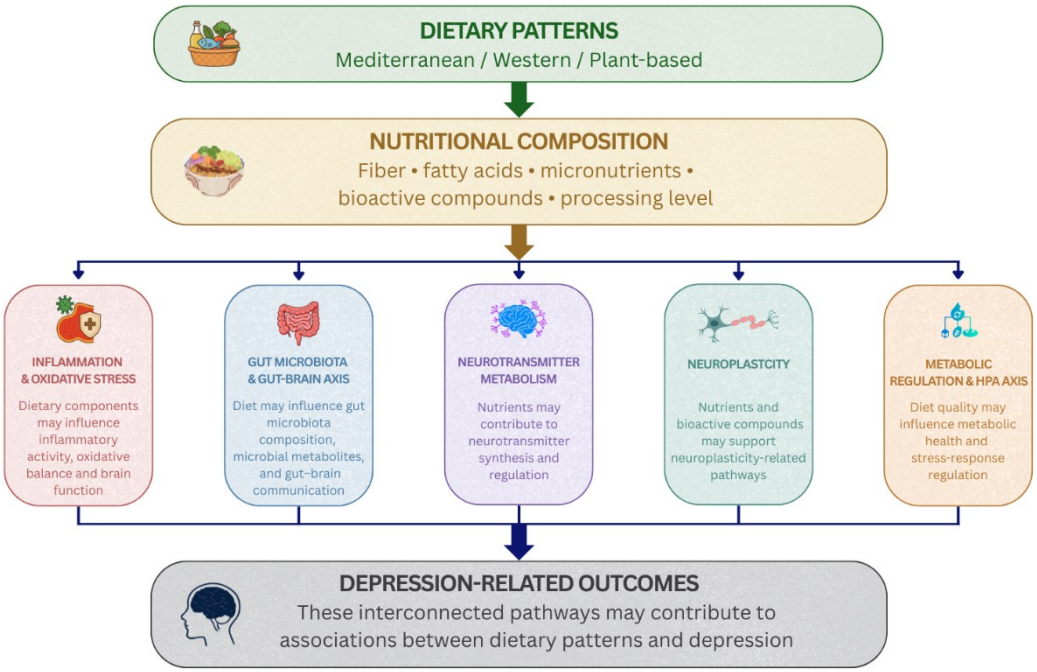

Figure 1. Proposed biological pathways linking dietary patterns and depression

These mechanisms provide a theoretical framework for understanding how dietary patterns may contribute to depression risk and symptom severity (Marx et al., 2021). As such, they form the basis for the examination of specific dietary patterns and their associations with depression in the following chapters.

1.5 Aim of the Thesis

The aim of this thesis is to examine the association between different dietary patterns and depression in adults, with a particular focus on the Mediterranean diet, the Western dietary patterns and plant-based dietary patterns.

The primary objective is to analyze epidemiological evidence from observational studies, systematic reviews, and meta-analyses, while also exploring the biological mechanisms through which diet may influence depression. In addition, the thesis aims to critically evaluate important methodological limitations within the existing literature, including methodological challenges related to dietary assessment, study design, and interpretation of findings.

Overall, this thesis seeks to evaluate diet as a potentially modifiable factor within the multifactorial framework of depression.

CHAPTER 2

MEDITERRANEAN DIET AND DEPRESSION

2.1 Definition and Characteristics of the Mediterranean Diet

The Mediterranean diet is among the most extensively studied dietary patterns in the fields of nutrition and public health. It refers to the traditional dietary habits observed in populations living in the Mediterranean region, particularly in Greece and Southern Italy during the mid-20th century (Keys et al., 1986; Martínez-González et al., 2019; Trichopoulou et al., 2003). Although dietary practices differ across Mediterranean countries, the term Mediterranean diet is generally used to describe a broad dietary pattern based on common traditional food characteristics rather than a single standardized diet (Bach-Faig et al., 2011; Davis et al., 2015; Martínez-González et al., 2019).

The Mediterranean dietary pattern is characterized by a high intake of plant-based foods, including vegetables, fruits, legumes, nuts, seeds, and whole grains. Olive oil serves as the primary source of added fat, while fish and seafood are consumed on a regular basis. Moderate consumption of dairy products, particularly yogurt and cheese, together with a limited intake of red meat, processed meat, and sweets, are also recognized as typical features of this dietary model (Bach-Faig et al., 2011; Estruch et al., 2018; Martínez-González et al., 2019).

One of the defining characteristics of the Mediterranean diet is that it represents an overall dietary pattern rather than an intervention focused on individual foods or isolated nutrients. Dietary pattern approaches take into account the combination, variety, and frequency of foods consumed together, thereby providing a more realistic representation of habitual dietary behaviors (Hu, 2002; Jacobs & Tapsell, 2013; Martínez-González et al., 2019).

Beyond food choices, the traditional Mediterranean diet also encompasses cultural and behavioral aspects associated with eating practices, including a preference for seasonal and minimally processed foods, traditional culinary methods, and the social dimension of meals (Bach-Faig et al., 2011)**.** Consequently, researchers often describe the Mediterranean diet as a multidimensional dietary model shaped by geographical, cultural, and lifestyle factors (Bach-Faig et al., 2011; Davis et al., 2015)**.** The main food groups, consumption frequency, and lifestyle components that characterize the Mediterranean dietary pattern are summarized in Figure 2.

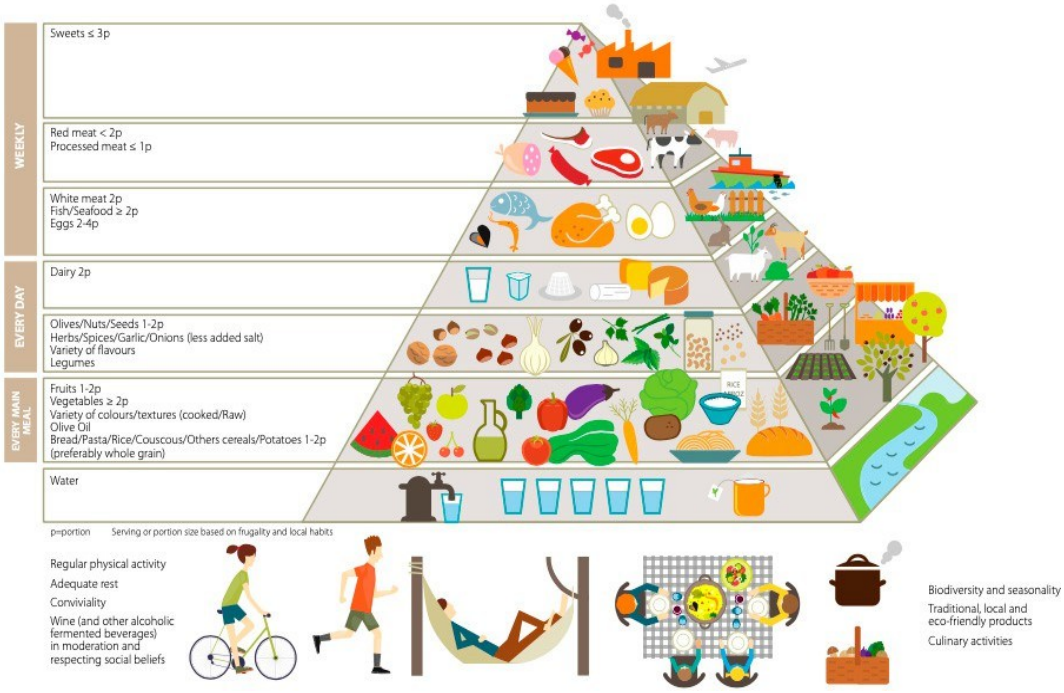

Figure 2. Updated Mediterranean Diet Pyramid with sustainability recommendations. Adapted from (Serra-Majem et al., 2020).

In epidemiological studies, adherence to the Mediterranean diet is commonly assessed using scoring systems such as the Mediterranean Diet Score (MDS) and the alternate Mediterranean Diet Score (aMED) (Fung et al., 2006; Trichopoulou et al., 2003). These tools measure how closely individuals follow the key characteristics of the Mediterranean dietary pattern by assigning scores according to their consumption of both typical and non-typical Mediterranean food groups (Fung et al., 2006; Trichopoulou et al., 2003).

Despite the availability of several adherence scores, no single definition of the Mediterranean diet has been universally accepted (Davis et al., 2015). Differences in geographical location, food availability, cultural traditions, and methodological approaches can influence how adherence is defined and measured across studies (Bach-Faig et al., 2011; Davis et al., 2015). Therefore, variations in Mediterranean diet definitions and scoring indexes should be taken into account when comparing findings from different populations (Davis et al., 2015).

2.2 Nutritional Composition and Anti-inflammatory Properties

The Mediterranean diet has attracted substantial scientific attention due to its nutritional composition and its potential anti-inflammatory effects (Bonaccio et al., 2015). This dietary pattern is characterized by a combination of beneficial nutritional components, including high amounts of dietary fiber, unsaturated fatty acids, vitamins, minerals, and a wide range of bioactive compounds derived primarily from plant-based foods and olive oil (Sofi et al., 2014; Martínez-González et al., 2019).

One of the central components of the Mediterranean diet is olive oil, particularly extra virgin olive oil, which represents the principal source of dietary fat in traditional Mediterranean populations (Bach-Faig et al., 2011; Estruch et al., 2018). Olive oil is rich in monounsaturated fatty acids, especially oleic acid, and also contains numerous bioactive compounds, including polyphenols with antioxidant properties (Gantenbein & Kanaka-Gantenbein, 2021). Together, these characteristics contribute to the favorable nutritional profile of the Mediterranean dietary pattern and are considered important elements of its potential health benefits (Gantenbein & Kanaka-Gantenbein, 2021; Martínez-González et al., 2019).

Fish and seafood are also key components of the Mediterranean diet because of their high content of omega-3 polyunsaturated fatty acids (Calder, 2015; Martínez-González et al., 2019). Omega-3 fatty acids, particularly EPA and DHA, are biologically important nutrients involved in numerous physiological processes, including the regulation of inflammatory responses (Calder, 2015). Within the Mediterranean dietary pattern, these fatty acids are obtained primarily through the regular consumption of fish and seafood (Martínez-González et al., 2019).

Another defining characteristic of the Mediterranean diet is its high consumption of vegetables, fruits, legumes, and whole grains (Bach-Faig et al., 2011; Martínez-González et al., 2019). These foods provide significant amounts of dietary fiber, vitamins, minerals, and phytochemicals, including flavonoids, carotenoids, and polyphenols (Liu, 2013; Zamora-Ros et al., 2016). Fruits and vegetables are also important sources of antioxidant compounds, while legumes and whole grains supply complex carbohydrates and dietary fiber, contributing to the overall nutritional value of the diet (Liu, 2013; Slavin, 2013).

The anti-inflammatory profile of the Mediterranean diet is considered one of its most important nutritional characteristics (Bonaccio et al., 2015; Casas et al., 2014). This dietary pattern is generally associated with a higher intake of foods rich in bioactive compounds with anti-

inflammatory properties and a lower intake of foods linked to a more pro-inflammatory nutritional profile (Bonaccio et al., 2015; Casas et al., 2014)**.** Studies that have assessed dietary inflammatory potential using the Dietary Inflammatory Index have shown that dietary patterns characterized by greater consumption of anti-inflammatory food components tend to have lower inflammatory scores (Shivappa et al., 2014)**.**

Overall, the Mediterranean diet represents a nutrient-dense dietary model characterized by a high intake of vegetables, fruits, legumes, whole grains, olive oil, and fish. The combination of dietary fiber, unsaturated fatty acids, and a variety of bioactive compounds contributes to its favorable nutritional composition and well-recognized anti-inflammatory profile (Bonaccio et al., 2017; Martínez-González et al., 2019).

2.3 Mediterranean Diet and Risk of Depression

The relationship between the Mediterranean diet and depression has been widely investigated in nutritional epidemiology over the past two decades (Lassale et al., 2019)**.** Several observational studies have suggested that greater adherence to the Mediterranean dietary pattern is associated with a lower incidence of depression and fewer depressive symptoms (Sánchez-Villegas et al., 2009; Skarupski et al., 2013)

One of the most important prospective cohort studies examining this association was conducted within the SUN Project by Sánchez-Villegas et al. (2009). This longitudinal study followed a cohort of Spanish university graduates and found that participants with higher adherence to the Mediterranean dietary pattern had a reduced risk of developing depression during the follow-up period. The findings provided prospective evidence supporting a potential association between adherence to the Mediterranean diet and the future risk of depression (Sánchez-Villegas et al., 2009).

Similar findings have been reported in other observational studies conducted across different populations. For example, Skarupski et al. (2013) examined older adults and observed that greater adherence to a Mediterranean-style dietary pattern was associated with fewer depressive symptoms over time. Other population-based studies have likewise reported inverse associations between Mediterranean diet adherence and depressive symptoms, supporting the consistency of these findings across diverse population groups.

Research conducted in a variety of settings has provided further evidence regarding the relationship between Mediterranean dietary patterns and depressive outcomes (Lai et al., 2014; Lassale et al., 2019). Studies involving older adults have also reported that higher adherence to the Mediterranean diet is associated with fewer depressive symptoms over time, further supporting the findings observed in other populations (Skarupski et al., 2013).

Several studies have examined the relationship between the Mediterranean diet and depression using Mediterranean diet adherence scores and indexes (Lassale et al., 2019). These assessment tools enable researchers to evaluate how closely individuals adhere to the key characteristics of the Mediterranean dietary pattern and to compare levels of dietary adherence across different populations (Trichopoulou et al., 2003). In observational studies, higher adherence scores have generally been associated with fewer depressive symptoms and a lower risk of depression (Sánchez-Villegas et al., 2009; Skarupski et al., 2013). Findings from systematic reviews and meta-analyses have further reinforced these observations, providing additional support for the association between Mediterranean diet adherence and improved mental health outcomes (Lai et al., 2014; Lassale et al., 2019).

Lai et al. (2014) reported that healthy dietary patterns characterized by higher consumption of fruits, vegetables, whole grains, and fish were associated with lower odds of depression. Similarly, Lassale et al. (2019) found that greater adherence to healthy dietary indexes, including Mediterranean dietary patterns, was associated with a reduced risk of depressive outcomes.

A systematic review and meta-analysis conducted by Lassale et al. (2019) further explored this association. The study examined the relationship between dietary indexes and depressive outcomes and concluded that stronger adherence to healthy dietary patterns, particularly the Mediterranean diet, was associated with a lower risk of depressive outcomes across observational studies (Lassale et al., 2019). Although the findings from observational studies and meta-analyses are generally consistent, they should be interpreted with caution, as observed associations do not necessarily imply causality (Lassale et al., 2019; Molendijk et al., 2018)**.** Researchers have emphasized the need for additional evidence from dietary interventions and randomized controlled trials to better determine whether Mediterranean dietary patterns can directly influence depressive outcomes (Molendijk et al., 2018)**.**

Overall, the available evidence suggests that greater adherence to the Mediterranean dietary pattern is associated with more favorable depressive outcomes (Lai et al., 2014; Lassale et al., 2019).

While these findings point toward a potentially protective relationship, the current evidence should be viewed within the context of an evolving field of research, where further studies are needed to clarify the role of the Mediterranean diet in depression-related outcomes (Lassale et al., 2019; Molendijk et al., 2018).

2.4 Clinical Trials and Dietary Interventions

Although observational studies provide important evidence regarding the association between the Mediterranean diet and depression, randomized controlled trials and dietary intervention studies are essential for determining whether dietary modifications can directly influence depressive symptoms (Jacka et al., 2017; Molendijk et al., 2018). In recent years, several intervention studies have explored whether improving dietary quality through Mediterranean-style dietary interventions may lead to reductions in depressive symptoms (Jacka et al., 2017; Parletta et al., 2019). These studies represent an important progression from observational research, offering the opportunity to evaluate the effects of dietary modification within clinical settings.

One of the most influential randomized controlled trials in this field is the SMILES trial conducted by Jacka et al. (2017). This study involved adults with major depressive disorder and examined whether dietary improvement based on Mediterranean dietary principles could influence depressive symptoms. Participants in the intervention group received nutritional counseling aimed at increasing the consumption of vegetables, fruits, legumes, whole grains, olive oil, nuts, and fish, while reducing the intake of processed foods, sweets, and refined products (Jacka et al., 2017; Opie et al., 2018). The researchers reported significantly greater improvements in depressive symptoms among participants in the dietary intervention group compared with those in the social support control group (Jacka et al., 2017). The SMILES trial provided important clinical evidence suggesting that structured dietary modification may contribute to improvements in depressive symptoms (Jacka et al., 2017).

Another notable dietary intervention study was the HELFIMED trial conducted by Parletta et al. (2019). This randomized controlled trial examined the effects of a Mediterranean-style dietary intervention in individuals experiencing depressive symptoms. Participants assigned to the dietary intervention showed improvements in both depressive symptoms and overall dietary quality compared with the control group (Parletta et al., 2019). These findings offered further evidence

that Mediterranean-style dietary interventions may provide benefits for individuals experiencing depressive symptoms (Parletta et al., 2019).

The AMMEND trial conducted by Bayes et al. (2022) also investigated the effects of a Mediterranean dietary intervention on depressive symptoms. The study included young men experiencing depressive symptoms and assessed the impact of a Mediterranean-style diet on the severity of those symptoms. Participants who followed the Mediterranean dietary intervention demonstrated significant reductions in depressive symptoms compared with the control group (Bayes et al., 2022). By focusing on a younger adult population, this study contributed additional evidence to the growing body of research in this area (Bayes et al., 2022).

Further evidence has emerged from larger dietary intervention studies that were originally designed to investigate cardiovascular disease prevention. The PREDIMED trial evaluated the effects of Mediterranean dietary interventions supplemented with extra virgin olive oil or nuts on cardiovascular outcomes (Estruch et al., 2018). Secondary analyses of the PREDIMED data examined depression-related outcomes and suggested a potential association between Mediterranean dietary intervention and a reduced risk of depression in certain populations (Sánchez-Villegas et al., 2013).

Overall, clinical trials and dietary intervention studies provide evidence that complements findings from observational research regarding the potential relationship between the Mediterranean diet and depression (Bayes et al., 2022; Jacka et al., 2017; Parletta et al., 2019). Current findings suggest that Mediterranean-style dietary interventions may contribute to improvements in depressive symptoms, although further research is needed to better understand the underlying mechanisms and long-term effects (Bayes et al., 2022; Jacka et al., 2017; Parletta et al., 2019).

2.5 Possible Biological Mechanisms

Several biological mechanisms may account for the beneficial association identified between adherence to the Mediterranean dietary pattern and depression (Bayes et al., 2020; Marx et al., 2021). As outlined in Chapter 1, depression is increasingly recognized as a multifaceted disorder characterized by interconnected processes, including inflammation, oxidative stress, alterations in the gut microbiota, reduced neuroplasticity, and metabolic dysfunction (Berk et al., 2013; Marx et al., 2021). The Mediterranean diet has received substantial scientific interest due to its nutritional

profile, which may positively affect multiple underlying pathways involved in depression simultaneously (Bayes et al., 2020; Marx et al., 2021).

One of the most widely proposed mechanisms is linked to the anti-inflammatory properties of the Mediterranean diet (Bayes et al., 2020; Marx et al., 2021). This dietary pattern is characterized by a high intake of fruits, vegetables, legumes, nuts, olive oil, and fish, which are rich sources of omega-3 fatty acids, polyphenols, antioxidants, and dietary fiber (Gorzynik-Debicka et al., 2018; Martínez-González et al., 2019). These nutritional components have been associated with reduced inflammatory potential and more favorable profiles of inflammatory biomarkers (Bonaccio et al., 2017). It has been suggested that such effects may partly explain the association observed between adherence to the Mediterranean diet and the presence of depressive symptoms (Bayes et al., 2020; Marx et al., 2021).

The Mediterranean diet may also contribute to a healthier gut microbiota composition due to its high consumption of fiber-rich foods (De Filippis et al., 2016; Tosti et al., 2018). An increased availability of fermentable substrates may enhance microbial diversity and promote the growth of microbial communities associated with more favorable metabolic and inflammatory profiles (De Filippis et al., 2016; Tosti et al., 2018). Given the recognized role of the gut microbiota in emotional regulation and mental health, this pathway is increasingly viewed by researchers as a potential mechanism underlying the association between the Mediterranean diet and depression (Berding et al., 2021; Cheung et al., 2019).

Another proposed mechanism relates to the regulation of oxidative balance (Bayes et al., 2020; Marx et al., 2021). The Mediterranean dietary pattern includes a broad range of foods rich in antioxidants, such as fruits, vegetables, olive oil, nuts, and legumes (Gorzynik-Debicka et al., 2018; Romagnolo & Selmin, 2017). These foods provide bioactive compounds, including polyphenols, carotenoids, and flavonoids, which may support antioxidant defenses and help protect cells from oxidative damage (Romagnolo & Selmin, 2017; Widmer et al., 2015). Such antioxidant-related properties may represent one of the biological pathways through which the Mediterranean diet influences processes associated with depression (Bayes et al., 2020; Marx et al., 2021).

Researchers have also emphasized the potential contribution of the Mediterranean diet to metabolic pathways associated with mental health (Marx et al., 2021). Sustained adherence to this dietary pattern has been linked to more favorable metabolic profiles, including improvements in

factors related to insulin regulation and overall metabolic functioning (Dinu et al., 2018; Sofi et al., 2014). Given that metabolic dysfunction commonly co-occurs with depression, enhanced metabolic regulation may represent an additional pathway through which the Mediterranean diet is associated with mental health outcomes (Firth et al., 2020; Marx et al., 2021).

Finally, the Mediterranean diet provides a range of nutrients that play important roles in normal brain function, including omega-3 fatty acids, folate, magnesium, zinc, and B vitamins (Marx et al., 2017; Sarris et al., 2015). Rather than exerting its effects through a single biological mechanism, this dietary pattern is believed to influence multiple interconnected pathways simultaneously (Marx et al., 2021). Researchers increasingly suggest that any potential mental health benefits are unlikely to result from an individual nutrient alone, but rather from the combined influence of the overall dietary pattern and the interactions among its various components (Firth et al., 2020; Marx et al., 2021).

Although growing evidence supports the biological plausibility of these associations, current research has not yet established definitive causal mechanisms (Bayes et al., 2020; Marx et al., 2021). Nevertheless, the overall nutritional composition of the Mediterranean diet offers a strong theoretical framework for understanding its potential relevance in depression-related research (Marx et al., 2021).

2.6 Limitations of Current Evidence

Despite the growing body of evidence linking the Mediterranean diet to lower levels of depressive symptoms, several limitations specific to this dietary pattern should be considered when interpreting current findings (Lassale et al., 2019; Molendijk et al., 2018). Differences in the definition of the Mediterranean dietary pattern and variations in adherence scoring systems may contribute to heterogeneity across studies, making direct comparisons of findings more challenging (Davis et al., 2015; Lassale et al., 2019).

In addition to these challenges, Mediterranean-style dietary intervention studies also present several important limitations (Jacka et al., 2017; Opie et al., 2018). Although studies such as SMILES and HELFIMED reported reductions in depressive symptoms following Mediterranean-style dietary interventions, they were characterized by relatively small sample sizes and limited follow-up durations (Jacka et al., 2017; Parletta et al., 2019). Blinding participants in nutritional intervention studies remains challenging, as individuals are typically aware of the dietary changes

being introduced (Opie et al., 2018). Furthermore, dietary interventions often include counseling and ongoing participant support, which may act as additional influences and should be taken into account when interpreting study outcomes (Opie et al., 2018).

Population differences further complicate the interpretation of the current evidence base (Lassale et al., 2019; Quirk et al., 2013). The characteristics of Mediterranean dietary patterns may vary across countries and cultural contexts due to differences in food availability, traditional eating habits, and socioeconomic factors (Davis et al., 2015; Martínez-González et al., 2019). As a result, Mediterranean diet adherence scores developed within Mediterranean populations may not fully capture dietary behaviors in non-Mediterranean settings, potentially contributing to variability in study findings (Davis et al., 2015; Lassale et al., 2019).

Another challenge relates to the maintenance and accurate assessment of long-term dietary adherence in Mediterranean diet research (Lassale et al., 2019; Opie et al., 2018). Dietary interventions require sustained behavioral modification, and variations in participant adherence may affect the interpretation of intervention outcomes (Opie et al., 2018). In addition, differences in intervention duration, the level of dietary support provided, and the methods used to assess adherence create further difficulties when comparing results across clinical studies (Opie et al., 2018).

Overall, although current evidence suggests an association between adherence to the Mediterranean diet and depressive outcomes, these specific limitations should be considered when interpreting these findings (Lassale et al., 2019; Molendijk et al., 2018). Future research incorporating larger randomized controlled trials, extended follow-up periods, and improved evaluation of dietary adherence is required to further clarify the relationship between the Mediterranean diet and depression (Molendijk et al., 2018; Opie et al., 2018).

CHAPTER 3

WESTERN DIET AND DEPRESSION

3.1 Definition and Characteristics of the Western Diet

The Western dietary pattern is a contemporary nutritional model that emerged largely as a result of industrialization, urbanization, and substantial transformations in food production and distribution systems (Cordain et al., 2005; Popkin et al., 2012). In contrast to traditional dietary patterns, which are typically characterized by a higher consumption of minimally processed foods, the Western diet is generally associated with increased intake of energy-dense products, refined food items, and highly processed foods (Cordain et al., 2005; Monteiro et al., 2019; Myles, 2014). While definitions of the Western diet differ somewhat across the literature, this dietary pattern is consistently identified by several common nutritional features (Cordain et al., 2005; Zinöcker & Lindseth, 2018). These features include elevated consumption of refined grains, added sugars, sugar-sweetened beverages, processed foods, red and processed meats, fried foods, and products high in saturated fats (Cordain et al., 2005; Statovci et al., 2017).

The emergence of the Western dietary pattern has been strongly linked to the global nutrition transition, a phenomenon characterized by a shift from traditional dietary habits toward eating patterns that include higher quantities of processed foods, animal-based products, added sugars, and edible oils (Cordain et al., 2005; Popkin et al., 2012). This transition has developed in parallel with economic growth, the globalization of food systems, and the expanding availability of industrially manufactured food products (Monteiro et al., 2019; Popkin et al., 2012).

A key feature of the contemporary Western diet is the growing proportion of ultra-processed foods within overall dietary intake (Monteiro et al., 2019; Zinöcker & Lindseth, 2018). Under the NOVA food classification system, ultra-processed foods are defined as industrial formulations that undergo multiple stages of processing and typically contain ingredients such as refined substances, additives, and components that are seldom used in traditional food preparation (Monteiro et al., 2019). These products are generally formulated to be convenient, highly palatable, and ready for consumption, factors that have contributed to their increasing incorporation into modern eating patterns (Monteiro et al., 2019; Moubarac et al., 2014).

Ultra-processed foods typically encompass products such as packaged snack items, confectionery products, soft drinks, and a wide range of ready-to-eat industrially manufactured formulations

(Monteiro et al., 2019). The growing availability and consumption of these products constitute a significant distinction between traditional dietary patterns and modern Western dietary models (Moubarac et al., 2014; Zinöcker & Lindseth, 2018).

Another notable characteristic of the Western diet is its overall food composition, which differs substantially from that of traditional dietary patterns (Cordain et al., 2005; García-Montero et al., 2021). Together, these characteristics define the Western dietary pattern and distinguish it from more traditional dietary models.

3.2 Nutritional Profile and Health-Related Characteristics

The nutritional composition of the Western dietary pattern has been extensively investigated due to its distinct nutrient profile compared with dietary models that are primarily based on minimally processed foods (García-Montero et al., 2021; Malesza et al., 2021). In addition to differences in food group consumption, the Western diet is generally linked to significant alterations in the intake of macronutrients, micronutrients, and bioactive compounds that are regularly consumed (Clemente-Suárez et al., 2023; García-Montero et al., 2021).

One of the defining nutritional features of the Western diet is its elevated energy density, largely attributable to the frequent intake of foods high in refined carbohydrates and added fats (Clemente-Suárez et al., 2023; Malesza et al., 2021). Energy-dense dietary patterns can provide substantial amounts of calories while simultaneously containing lower levels of several essential micronutrients and other dietary components associated with a high-quality diet (Clemente-Suárez et al., 2023; Drewnowski & Specter, 2004).

The Western dietary pattern is further distinguished by a carbohydrate composition that differs from that of less processed dietary models (Cordain et al., 2005; Ludwig et al., 2018). In Western-style diets, a considerable proportion of carbohydrate intake is typically obtained from refined grains and added sugars rather than from fiber-rich foods such as whole grains and legumes (Cordain et al., 2005; Reynolds et al., 2019). As a result, these dietary patterns are often associated with lower dietary fiber intake, which is considered one of the most important nutritional differences between highly processed and minimally processed diets (García-Montero et al., 2021; Malesza et al., 2021).

Dietary fiber represents an important component of overall diet quality because fiber-containing foods contribute to nutrient intake and influence several physiological processes (Reynolds et al.,

2019; Stephen et al., 2017). Lower intake of fiber-rich foods within Western dietary patterns is frequently accompanied by reduced consumption of vegetables, fruits, legumes and whole grains (García-Montero et al., 2021; Malesza et al., 2021).

The lipid composition of Western dietary patterns has also received considerable attention in nutritional research (Calder, 2015; Simopoulos, 2016). Western-style diets are generally characterized by higher intake of certain saturated fats and an altered balance of dietary fatty acids compared with traditional dietary models (Cordain et al., 2005; Malesza et al., 2021). Researchers suggest that overall dietary fat quality, rather than only total fat intake, represents an important factor when evaluating the health-related characteristics of dietary patterns (Calder et al., 2011; Minihane et al., 2015).

These nutritional characteristics provide an important context for understanding the reported associations between Western dietary patterns and depression.

3.3 Western Dietary Pattern and Risk of Depression

The association between Western dietary patterns and depression has attracted growing interest in the field of nutritional psychiatry (Li et al., 2017). Whereas earlier investigations primarily examined the role of individual nutrients, more recent studies have shifted their focus toward overall dietary patterns, as habitual food combinations may provide a more accurate reflection of real-world dietary intake (Akbaraly et al., 2009; Hu, 2002; Jacka et al., 2010).

A notable prospective study exploring this relationship was carried out by Akbaraly et al. (2009) using data from the Whitehall II cohort. The researchers identified two principal dietary patterns, termed the “whole food” and “processed food” patterns, and evaluated their associations with depressive symptoms over the follow-up period (Akbaraly et al., 2009). The findings indicated that greater adherence to the processed food pattern, characterized by higher consumption of processed meats, fried foods, refined grains, and high-fat products, was associated with an increased likelihood of experiencing depressive symptoms several years later (Akbaraly et al., 2009).

Similar results were reported by Jacka et al. (2010) in a population-based study that examined the relationship between dietary patterns and mental health among women. The researchers observed that greater adherence to a Western dietary pattern was associated with a higher likelihood of depressive and anxiety symptoms, whereas dietary patterns characterized by lower consumption

of processed foods demonstrated the opposite relationship (Jacka et al., 2010). These findings supported the proposition that overall diet quality may play a role in mental health outcomes (Jacka et al., 2010; Li et al., 2017).

Research involving younger populations has likewise indicated potential associations between Western-style eating habits and mental health outcomes (Oddy et al., 2009; Weng et al., 2012). In a study of adolescents, Oddy et al. (2009) reported that adherence to a Western dietary pattern was linked to less favorable mental health indicators, while healthier dietary patterns were associated with more positive outcomes (Oddy et al., 2009). Comparable findings have been documented in other adolescent studies, suggesting that unhealthy dietary patterns may be associated with a greater prevalence of depressive symptoms in this age group (Weng et al., 2012).

Longitudinal research has provided further insight into the temporal association between dietary patterns and depressive symptoms (Le Port et al., 2012; Li et al., 2017). In a large adult cohort study, Le Port et al. (2012) assessed dietary patterns and monitored changes in depressive symptoms over time. The results indicated that less healthy dietary patterns were associated with the presence of depressive symptoms during the follow-up period (Le Port et al., 2012).

Studies conducted across diverse populations have continued to explore the relationship between unhealthy dietary patterns and depressive outcomes (Li et al., 2017). Nevertheless, the evidence from individual observational studies has not always been entirely consistent, as some investigations have identified variations in findings according to the dietary pattern evaluated and the characteristics of the population under study (Kim et al., 2016). These observations underscore the importance of considering overall dietary patterns, population-specific differences, and methodological heterogeneity when interpreting associations between diet and depression (Hu, 2002; Kim et al., 2016).

Systematic reviews and meta-analyses have provided additional insight into the overall body of evidence linking unhealthy dietary patterns to depression (Li et al., 2017). In their meta-analysis of observational studies, Li et al. (2017) examined the association between various dietary patterns and depression risk, reporting that unhealthy dietary patterns, including Western-style diets, were generally linked to a greater risk of depression, whereas healthier dietary patterns were associated with a reduced risk of depressive outcomes (Li et al., 2017).

More recent review studies have extended these findings by focusing on Western dietary patterns and specific food groups that are characteristic of this dietary model (Zhang et al., 2023). Zhang

et al. (2023) reported that Western dietary patterns, together with several food groups commonly consumed within these diets, were associated with less favorable mental health outcomes, including the presence of depressive symptoms (Zhang et al., 2023).

Although numerous studies have reported associations between Western dietary patterns and depressive symptoms, these findings should be interpreted cautiously, as much of the available evidence originates from observational research (Li et al., 2017; Zhang et al., 2023). While observational studies play an important role in identifying potential relationships between dietary habits and mental health outcomes, they cannot conclusively determine whether adherence to Western dietary patterns directly contributes to the development of depression (Li et al., 2017).

Overall, the existing evidence suggests that greater adherence to Western-style dietary patterns is generally associated with a higher risk of depressive symptoms or depression across diverse populations (Akbaraly et al., 2009; Jacka et al., 2010; Li et al., 2017). However, these associations should be interpreted within the context of methodological limitations, population-specific variations, and the heterogeneity reported across individual studies (Li et al., 2017; Zhang et al., 2023).

3.4 Characteristic Foods of the Western Diet and Their Association with Depression

Although growing research attention has shifted toward overall dietary patterns, several individual dietary components commonly found in Western-style diets have also been examined in relation to depression and depressive symptoms (Lane et al., 2022; Sánchez-Villegas et al., 2012). Investigating these specific components may provide a clearer understanding of how particular features of unhealthy dietary patterns are associated with mental health outcomes (Lane et al., 2022).

Among the dietary components commonly found in Western dietary patterns, ultra-processed foods have received particular attention because they represent one of the defining characteristics of this dietary model (Lane et al., 2022; Monteiro et al., 2019). Prospective studies have suggested a potential association between higher consumption of ultra-processed foods and adverse depressive outcomes (Adjibade et al., 2019). In a large French cohort, Adjibade et al. (2019) investigated the relationship between ultra-processed food intake and the development of depressive symptoms, reporting that greater consumption was associated with an increased risk of incident depressive symptoms during the follow-up period (Adjibade et al., 2019).

Comparable findings were observed by Gómez-Donoso et al. (2020) in the SUN cohort, where the association between ultra-processed food consumption and depression incidence was examined. The researchers found that participants with higher levels of ultra-processed food intake had a greater risk of developing depression compared with those reporting lower consumption (Gómez-Donoso et al., 2020).

More recent evidence from population-based studies has further reinforced these observations (Hecht et al., 2022; Samuthpongtorn et al., 2023). Samuthpongtorn et al. (2023) assessed ultra-processed food consumption among women and found that higher intake, particularly of specific categories of ultra-processed foods, was associated with an elevated risk of depression (Samuthpongtorn et al., 2023). Similarly, Hecht et al. (2022) reported that greater consumption of ultra-processed foods was linked to a higher frequency of adverse mental health symptoms among adults.

This relationship has also been explored in systematic reviews and meta-analyses (Lane et al., 2022). According to Lane et al. (2022) higher consumption of ultra-processed foods was associated with an increased likelihood of depressive and anxiety-related outcomes across observational studies. Collectively, these findings illustrate the growing scientific interest in ultra-processed food intake as a key component of Western dietary patterns and its potential relevance to mental health outcomes (Lane et al., 2022).

Another frequently examined component of Western-style dietary patterns is the high consumption of added sugars and refined carbohydrates (Gangwisch et al., 2015; Knüppel et al., 2017). Gangwisch et al. (2015) investigated the association between dietary glycemic index and depression risk among postmenopausal women, reporting that diets characterized by higher glycemic index values were associated with an increased risk of incident depression during the follow-up period.

The relationship between sugar intake and depressive outcomes has also been explored in several studies (Knüppel et al., 2017). Knüppel et al. (2017) assessed sugar consumption from sweet foods and beverages and found that higher levels of sugar intake were associated with a greater risk of common mental disorders in certain analyses.

Particular attention has been given to sugar-sweetened beverages, which represent a major source of added sugars in many Western diets and have been widely investigated in relation to depression (Hu et al., 2019). A meta-analysis conducted by Hu et al. (2019) reported that higher consumption

of sugar-sweetened beverages was associated with an elevated risk of depression across observational studies. Furthermore, dose-response evidence has indicated that progressively greater intake of sugar-sweetened beverages may be linked to a higher likelihood of depression (Wang et al., 2022).

Fast foods and commercially prepared products constitute another category of foods frequently linked to Western dietary patterns (Cordain et al., 2005; Sánchez-Villegas et al., 2012). In a prospective study, Sánchez-Villegas et al. (2012) examined the consumption of fast foods and commercially baked products and found that higher intake was associated with an increased risk of incident depression during the follow-up period (Sánchez-Villegas et al., 2012).

The association between red and processed meat consumption and depression has also been investigated, although the available findings remain inconsistent across studies (Nucci et al., 2020). A systematic review and meta-analysis conducted by Nucci et al. (2020) evaluated the existing evidence regarding red and processed meat intake and depression risk, while highlighting the considerable heterogeneity observed among individual studies (Nucci et al., 2020).

Overall, current evidence indicates that several dietary components commonly found in Western dietary patterns, particularly ultra-processed foods, products high in added sugars, and fast foods, are associated with a greater prevalence or risk of depressive outcomes (Hu et al., 2019; Lane et al., 2022; Sánchez-Villegas et al., 2012). However, because foods are typically consumed as part of broader dietary patterns rather than in isolation, it remains difficult to completely disentangle the individual contribution of specific food groups from the overall dietary context (Hu, 2002; Lane et al., 2022).

3.5 Possible Biological Mechanisms

Several biological mechanisms have been suggested to account for the association between Western dietary patterns and depressive outcomes (Marx et al., 2021; Myles, 2014). Western-style diets have attracted research interest because of their potential involvement in biological processes related to inflammation, metabolic regulation, alterations in the gut microbiota, and neurobiological pathways implicated in depression (Madison & Kiecolt-Glaser, 2019; Malesza et al., 2021; Miller & Raison, 2016).

One of the most extensively investigated pathways linking Western dietary patterns to depression is chronic low-grade inflammation (Malesza et al., 2021; Miller & Raison, 2016). Due to their

overall nutritional composition and their influence on immune-related processes, Western-style dietary patterns are often regarded as having a greater inflammatory potential (Shivappa et al., 2014; Statovci et al., 2017).

The Dietary Inflammatory Index (DII) was developed as a tool for estimating the inflammatory potential of an individual's overall diet based on established relationships between dietary components and inflammatory biomarkers (Shivappa et al., 2014). Diets characterized by higher inflammatory scores often exhibit several features commonly associated with Western dietary patterns, including lower consumption of fiber-rich foods and differences in dietary components linked to inflammatory processes (Malesza et al., 2021; Shivappa et al., 2014).

Evidence from systematic reviews and meta-analyses has explored whether dietary patterns with greater inflammatory potential are associated with depressive outcomes (Chen et al., 2021; J. Wang et al., 2019). Wang et al. (2019) reported that higher Dietary Inflammatory Index scores were associated with an increased risk of depression, supporting the hypothesis that inflammatory mechanisms may represent one pathway through which diet quality influences depressive outcomes (Miller & Raison, 2016; J. Wang et al., 2019). Similarly, Chen et al. (2021) identified a positive dose-response association between pro-inflammatory dietary patterns and symptoms of both depression and anxiety in their meta-analysis (Chen et al., 2021).

Another proposed mechanism involves the association between Western dietary patterns and the gut microbiota (Madison & Kiecolt-Glaser, 2019; Zinöcker & Lindseth, 2018). Dietary habits are recognized as important environmental factors influencing the composition of the gut microbiome, and dietary patterns characterized by high consumption of highly processed foods and low intake of dietary fiber have been linked to alterations in gut microbial communities (Malesza et al., 2021; Zinöcker & Lindseth, 2018).

Research on the microbiota-gut-brain axis indicates that changes in gut microbial composition may affect pathways involved in immune function, metabolic regulation, and communication between the gastrointestinal tract and the central nervous system (Berding et al., 2021; Foster et al., 2017). Consequently, alterations in the gut microbiota have been proposed as a potential mechanism through which Western dietary patterns may influence mental health outcomes (Madison & Kiecolt-Glaser, 2019; Zinöcker & Lindseth, 2018).

Metabolic dysfunction has also been identified as a possible pathway linking Western dietary patterns with depression-related outcomes (Clemente-Suárez et al., 2023; Marx et al., 2021).

Western-style diets have been associated with adverse metabolic changes, including disruptions in glucose metabolism and broader metabolic regulatory processes (Clemente-Suárez et al., 2023; García-Montero et al., 2021).

The relationship between metabolic health and depression is widely regarded as bidirectional, with evidence indicating complex interactions among metabolic disturbances, inflammatory processes, and mental health disorders (Penninx & Lange, 2018). As a result, metabolic alterations associated with unhealthy dietary patterns may constitute another potential biological pathway linking Western dietary habits to depressive outcomes (Clemente-Suárez et al., 2023; Penninx & Lange, 2018).

Oxidative stress has likewise been proposed as a potential mechanism underlying the relationship between diet and depression (Black et al., 2015; Marx et al., 2021). Owing to differences in overall nutritional composition and a lower intake of foods rich in antioxidant compounds, Western dietary patterns may contribute to biological conditions associated with increased oxidative stress (García-Montero et al., 2021; Marx et al., 2021). However, oxidative stress is unlikely to operate as an isolated mechanism and is generally viewed as part of a broader network of interconnected processes involving inflammation and metabolic dysfunction (Black et al., 2015; Miller & Raison, 2016).

Overall, current evidence indicates that the association between Western dietary patterns and depression cannot be adequately explained by a single biological mechanism (Madison & Kiecolt-Glaser, 2019; Marx et al., 2021). Rather, Western-style diets may affect multiple interconnected pathways, including inflammatory activity, gut microbiota composition, metabolic regulation, and oxidative balance (Malesza et al., 2021; Marx et al., 2021). Nevertheless, additional research is needed to better understand the direction, magnitude, and underlying nature of these mechanisms within human populations (Berding et al., 2021; Marx et al., 2021).

3.6 Limitations of Current Evidence

Although the available evidence suggests an association between Western dietary patterns and depressive outcomes, several limitations related to the definition and characterization of this dietary pattern should be considered when interpreting current findings (Li et al., 2017; Zhang et al., 2023). One important limitation concerns the lack of a uniform definition of Western dietary patterns across nutritional research (Cordain et al., 2005; Zhang et al., 2023). Although Western-

style diets are generally characterized by high consumption of processed foods, refined products, and energy-dense items, the specific food groups included in these definitions may differ from one study to another (Cordain et al., 2005; Zhang et al., 2023). Such variations can complicate direct comparisons across studies and may contribute to the heterogeneity observed in reported associations (Li et al., 2017).

Another methodological issue relates to the approaches used to identify and measure dietary patterns (Hu, 2002; Newby & Tucker, 2004). Many studies examining dietary patterns, including Western-style diets, employ data-driven methods such as principal component analysis or factor analysis to derive dietary patterns within a particular population (Newby & Tucker, 2004). Because these techniques are based on the dietary habits observed in each study sample, a dietary pattern classified as "Western" may not reflect exactly the same dietary exposure across different cultural or geographic settings (Li et al., 2017; Newby & Tucker, 2004).

In addition to differences in defining Western dietary patterns, the assessment of ultra-processed food consumption also presents distinct methodological challenges (Lane et al., 2022; Monteiro et al., 2019). Although classification systems such as NOVA have provided a standardized framework for evaluating food processing levels, differences in dietary assessment instruments and the availability of detailed food information may affect the accuracy with which ultra-processed food intake is measured (Lane et al., 2022; Monteiro et al., 2019).

Another important limitation is the challenge of disentangling the effects of individual dietary components from those of the overall dietary pattern (Hu, 2002; Lane et al., 2022). Foods typically associated with Western dietary habits are often consumed in combination, making it difficult to determine whether the observed associations are attributable to specific foods, particular combinations of foods, or the overall quality of the diet (Hu, 2002; Lane et al., 2022).

Population-specific differences should also be taken into account when interpreting associations between Western dietary patterns and depression (Zhang et al., 2023). The composition and definition of a Western dietary pattern may differ according to geographical location, cultural practices, and stages of nutritional transition, which can limit the generalizability of findings across diverse populations (Popkin et al., 2012; Zhang et al., 2023).

Although the available evidence points to an association between Western dietary patterns and depressive outcomes, further research employing standardized dietary definitions and improved

characterization of Western dietary patterns is required to improve understanding of these relationships (Li et al., 2017; Zhang et al., 2023).

CHAPTER 4

PLANT-BASED DIET AND DEPRESSION

4.1 Definition and Main Characteristics of the Plant-Based Diets

Plant-based diets encompass a diverse range of dietary patterns that place greater emphasis on foods derived from plant sources, such as fruits, vegetables, legumes, whole grains, nuts, and seeds, while reducing or completely excluding foods of animal origin (Craig et al., 2009; Melina et al., 2016). Although the term is widely used in scientific literature and public health discourse, plant-based diets do not constitute a single, uniform dietary approach (Satija et al., 2016; T. Wang et al., 2023). Rather, they include a broad variety of eating patterns that differ according to the quantity and types of animal-derived foods that are consumed (Craig et al., 2009; T. Wang et al., 2023).

Traditionally, vegetarian and vegan diets have been regarded as the primary forms of plant-based dietary patterns (Craig et al., 2009; Melina et al., 2016). Among these, vegan diets are the most restrictive, as they exclude all foods derived from animals, including meat, poultry, fish, dairy products, and eggs (Melina et al., 2016). Vegetarian diets, in contrast, exclude meat and fish but may permit the consumption of other animal-derived products depending on the specific subtype (Craig et al., 2009; Melina et al., 2016). For instance, lacto-ovo vegetarian diets allow the intake of dairy products and eggs, whereas other vegetarian variations may include only certain categories of animal-derived foods (Craig et al., 2009; Melina et al., 2016).

However, the contemporary concept of a plant-based diet extends beyond the traditional definition of vegetarianism (Hemler & Hu, 2019). Many individuals who follow plant-based dietary patterns do not completely exclude animal products but instead prioritize plant-derived foods while reducing the frequency or quantity of animal food consumption (Satija et al., 2016; T. Wang et al., 2023). Consequently, current nutritional research increasingly views plant-based diets as existing along a continuum rather than as a strict distinction between vegetarian and omnivorous eating patterns (Hemler & Hu, 2019; Satija et al., 2016).

This distinction is important because simply reducing or eliminating animal-derived foods does not necessarily reflect the overall quality of a dietary pattern (Hemler & Hu, 2019; Satija et al., 2017). A diet may be classified as plant-based while still containing substantial amounts of refined grains, added sugars, and highly processed foods of plant origin (Satija et al., 2017). As a result,

recent research has moved beyond the traditional vegetarian versus non-vegetarian classification and has introduced dietary indices designed to evaluate both the quantity and quality of plant foods consumed (Satija et al., 2016, 2017).

One of the most widely used tools is the Plant-Based Diet Index (PDI), which was developed to measure adherence to plant-based dietary patterns while accounting for differences among food groups (Satija et al., 2016). This framework distinguishes between the overall Plant-Based Diet Index (PDI), the Healthy Plant-Based Diet Index (hPDI), and the Unhealthy Plant-Based Diet Index (uPDI) (Hemler & Hu, 2019; Satija et al., 2016). The hPDI places greater emphasis on healthier plant foods, including fruits, vegetables, legumes, nuts, and whole grains, whereas the uPDI assigns greater weight to less healthy plant-based foods such as refined grains, sweets, and sugar-sweetened beverages (Baden et al., 2019; Satija et al., 2017).

The development of these indices demonstrated that plant-based diets can vary substantially in their nutritional composition, even when they share a similar reduction in the consumption of animal-derived foods (Hemler & Hu, 2019; Satija et al., 2017). For instance, a dietary pattern centered on whole and minimally processed plant foods may provide a markedly different nutritional profile than a diet that excludes animal products but depends heavily on processed plant-based alternatives (Baden et al., 2019; Satija et al., 2017).

Another key characteristic of plant-based dietary patterns is the considerable variation observed across populations and cultural settings (Craig et al., 2009; Hemler & Hu, 2019). Factors such as food availability, personal food preferences, socioeconomic conditions, and individual motivations may influence how these dietary patterns are adopted and maintained in practice (Craig et al., 2009; Rosenfeld, 2018). While some individuals choose plant-based diets primarily for health-related purposes, others may follow them for environmental, ethical, or cultural reasons (Melina et al., 2016; Rosenfeld, 2018).

Overall, plant-based diets should be viewed as a diverse collection of dietary patterns rather than a single, standardized dietary approach (Craig et al., 2009; Medawar et al., 2019). Current evidence highlights the importance of differentiating between healthy and unhealthy forms of plant-based diets, as the quality of foods consumed and the overall dietary composition may significantly influence their health-related outcomes (Hemler & Hu, 2019; Satija et al., 2017).

4.2 Nutritional Composition and Health-Related Characteristics

The nutritional profile of plant-based diets is largely determined by the specific foods consumed, the diversity of the diet, and the extent to which animal-derived products are restricted or excluded (Bakaloudi et al., 2021; Neufingerl & Eilander, 2021). Although considerable variation exists among individuals following plant-based dietary patterns, diets that emphasize whole plant foods are generally associated with a higher intake of fruits, vegetables, legumes, whole grains, nuts, and seeds compared with many traditional omnivorous dietary patterns (Clarys et al., 2014; Parker & Vadiveloo, 2019; Rizzo et al., 2013).

A greater intake of minimally processed plant foods contributes to increased consumption of several beneficial dietary components, including dietary fiber, complex carbohydrates, and a variety of plant-derived bioactive compounds (Rizzo et al., 2013; Tuso et al., 2013). Studies comparing vegetarian and vegan dietary patterns with omnivorous diets have consistently reported higher average fiber intake among individuals adhering to plant-based diets (Clarys et al., 2014; Neufingerl & Eilander, 2021).

Differences in macronutrient composition have likewise been identified between plant-based and omnivorous dietary patterns (Clarys et al., 2014; Rizzo et al., 2013). Vegetarian and vegan diets typically contain lower amounts of saturated fatty acids and higher levels of unsaturated fatty acids, although these characteristics depend largely on the quality and types of foods consumed (Clarys et al., 2014; Hemler & Hu, 2019; Neufingerl & Eilander, 2021).

The quality of plant-based diets is an important factor influencing their overall nutritional characteristics (Parker & Vadiveloo, 2019; Satija et al., 2017). Dietary patterns centered on whole grains, fruits, vegetables, legumes, and nuts are generally considered nutritionally distinct from plant-based patterns characterized by high consumption of refined grains, added sugars, and highly processed plant-derived foods (Hemler & Hu, 2019; Satija et al., 2017).

Several studies have reported that individuals following vegetarian and vegan dietary patterns may achieve more favorable scores on dietary quality assessments compared with those consuming diets containing larger amounts of animal-based foods (Clarys et al., 2014; Parker & Vadiveloo, 2019). Findings from the Adventist Health Study indicated that vegetarian dietary patterns were associated with distinct nutrient profiles relative to non-vegetarian diets, including differences in fiber intake, fatty acid composition, and micronutrient consumption (Rizzo et al., 2013).

Despite these potential nutritional benefits, plant-based diets require careful consideration of specific nutrients that may be less readily available when animal-derived foods are substantially reduced or completely excluded (Bakaloudi et al., 2021; Neufingerl & Eilander, 2021). Achieving nutritional adequacy depends largely on appropriate food selection, the use of fortified products when needed, and well-planned dietary practices (Bakaloudi et al., 2021; Melina et al., 2016).

Vitamin B12 is among the most important nutrients that require attention in strict vegan diets, as its natural dietary sources are predominantly derived from animal-based foods (Bakaloudi et al., 2021; Neufingerl & Eilander, 2021; Watanabe et al., 2014). Evidence from systematic reviews suggests that individuals adhering to vegan diets may be at a greater risk of inadequate vitamin B12 status if appropriate supplementation or consumption of fortified foods is not ensured (Bakaloudi et al., 2021; Melina et al., 2016).

Additional nutrients frequently discussed in relation to plant-based dietary patterns include vitamin D, calcium, iodine, zinc, and iron (Neufingerl & Eilander, 2021; Schüpbach et al., 2017). Variations in the intake and nutritional status of these micronutrients may be observed among vegans, vegetarians, and omnivores as a result of differences in food sources, dietary composition, and nutrient bioavailability (Bakaloudi et al., 2021; Melina et al., 2016; Schüpbach et al., 2017).

Long-chain omega-3 fatty acids represent another important nutritional consideration for individuals following diets that exclude fish and seafood (Bakaloudi et al., 2021; Saunders et al., 2013). While plant-based foods can provide alpha-linolenic acid (ALA), the direct dietary intake of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) is generally lower among those who avoid marine food sources (Neufingerl & Eilander, 2021; Saunders et al., 2013).

Protein intake and protein quality have also been widely studied in relation to vegetarian and vegan dietary patterns (Mariotti & Gardner, 2019). Available evidence indicates that plant-based diets can provide sufficient protein when an adequate quantity and diversity of plant protein sources are incorporated into the diet (Mariotti & Gardner, 2019; Melina et al., 2016).

In addition to nutrient intake, plant-based dietary patterns have been explored for their association with broader health-related outcomes (Dinu et al., 2017; Hemler & Hu, 2019). Findings from systematic reviews and meta-analyses have linked vegetarian and healthful plant-based dietary patterns with more favorable cardiometabolic profiles, although these associations may be affected by variations in overall dietary quality and accompanying lifestyle factors (Dinu et al., 2017; Hemler & Hu, 2019).

Overall, the nutritional and health-related effects of plant-based diets are influenced by the interaction between beneficial dietary components, potential nutrient inadequacies, and the overall quality of the foods consumed (Bakaloudi et al., 2021; Hemler & Hu, 2019; Neufingerl & Eilander, 2021).

4.3 Plant-Based Diets and Risk of Depression

The association between plant-based dietary patterns and depression has attracted increasing interest within the field of nutritional psychiatry, although the available evidence remains mixed and findings differ according to the type of plant-based diet being examined (Iguacel et al., 2021; Jain et al., 2022). Research in this area includes studies investigating traditional vegetarian and vegan diets, as well as more recent approaches that assess the quality of plant-based food consumption through plant-based dietary indices (Iguacel et al., 2021; Lee et al., 2021).

Several observational studies have explored whether individuals adhering to vegetarian dietary patterns experience different levels of depressive symptoms compared with omnivorous populations (Bègue & Shankland, 2022; Matta et al., 2018). However, the findings have been inconsistent, with some studies reporting a higher prevalence of depressive symptoms among vegetarians, whereas others have identified only weak associations or no significant relationship after accounting for potential confounding factors (Bègue & Shankland, 2022; Matta et al., 2018; Storz & Ronco, 2023).

A large population-based investigation conducted within the French Constances cohort examined the relationship between vegetarian dietary patterns and depressive symptoms, reporting that this association was influenced by several factors, including the nature of dietary restrictions and individual participant characteristics (Matta et al., 2018). These findings suggest that the relationship between vegetarian diets and depression may not be attributable solely to the exclusion of animal-derived foods, but may also reflect the influence of broader behavioral and personal factors (Matta et al., 2018).

Similarly, Bègue and Shankland (2022) explored the association between vegetarianism and symptoms of anxiety and depression, emphasizing the challenges involved in establishing a direct causal relationship between dietary choices and mental health outcomes. Evidence derived from cross-sectional studies is unable to determine whether dietary patterns contribute to the

development of depressive symptoms or whether individuals experiencing psychological distress are more likely to alter their dietary behaviors (Bègue & Shankland, 2022; Iguacel et al., 2021).

Systematic reviews and meta-analyses have likewise produced mixed findings regarding the association between vegetarian diets and depressive outcomes (Iguacel et al., 2021; Jain et al., 2022). Some analyses have reported that vegetarian dietary patterns may be associated with higher depression scores compared with omnivorous diets; however, these results are marked by considerable heterogeneity across studies (Fazelian et al., 2022; Ocklenburg & Borawski, 2021).

The variability observed in the literature may be attributable to differences in study design, population characteristics, definitions of vegetarian dietary patterns, and the methods used to assess depressive symptoms (Iguacel et al., 2021; Jain et al., 2022). Consequently, treating vegetarian or vegan diets as a single, uniform dietary exposure may oversimplify the complex relationship between plant-based eating patterns and mental health outcomes (Iguacel et al., 2021; Lee et al., 2021).

More recent research has moved beyond simple comparisons between vegetarian and omnivorous diets and has increasingly focused on the overall quality of plant-based dietary patterns (Lee et al., 2021; Satija et al., 2017). This perspective acknowledges that plant-based diets can differ substantially in their nutritional composition and that the specific types of plant foods consumed may be more important than the mere exclusion of animal-derived foods (Lee et al., 2021; Satija et al., 2017).

Studies evaluating the quality of plant-based diets have suggested that healthier plant-based dietary patterns may be associated with more favorable depression-related outcomes (Lee et al., 2021; Zhang et al., 2025). Greater adherence to healthy plant-based dietary patterns, characterized by higher consumption of nutrient-dense plant foods, has been linked to lower levels of depressive symptoms in certain populations (Lee et al., 2021; Zhang et al., 2025).

In contrast, plant-based dietary patterns of lower nutritional quality may demonstrate different associations and have been related to less favorable psychological outcomes in some studies (Lee et al., 2021; Zhang et al., 2025). These findings indicate that the relationship between plant-based diets and depression may be influenced more by the quality of the dietary pattern than by the proportion of plant-derived foods alone (Lee et al., 2021; Zhang et al., 2025).

A longitudinal study has provided additional insight by investigating the relationship between plant-based dietary patterns and changes in depressive symptoms over time (Zhou et al., 2025).

The findings suggest that healthier forms of plant-based diets may be associated with more favorable trajectories of depressive symptoms, although further prospective research is needed to better understand and confirm these associations (Zhou et al., 2025).

Overall, the current body of evidence indicates that the relationship between plant-based diets and depression is multifaceted and cannot be adequately explained solely by the inclusion or exclusion of animal-derived foods or by dietary classification alone (Iguacel et al., 2021; Jain et al., 2022; Lee et al., 2021). The distinction between healthy and unhealthy plant-based dietary patterns appears to be a key factor that may account for some of the differences observed across previous studies (Lee et al., 2021; Zhang et al., 2025).

4.4 Clinical Trials and Dietary Interventions

Clinical evidence directly evaluating plant-based dietary interventions and depressive outcomes remains limited when compared with the larger body of observational research examining vegetarian, vegan, and plant-based dietary patterns (Iguacel et al., 2021; Jain et al., 2022). Several intervention studies investigating plant-based dietary modifications have focused primarily on mood-related outcomes rather than clinically diagnosed depression as the main endpoint (Agarwal et al., 2015; Beezhold & Johnston, 2012).

Beezhold and Johnston (2012) conducted a pilot randomized controlled trial involving omnivorous adults to investigate whether reducing the consumption of meat, fish, and poultry could affect mood states. Participants assigned to the vegetarian diet group demonstrated improvements in mood-related measures after two weeks compared with those in the other dietary groups (Beezhold & Johnston, 2012). This study is particularly relevant because dietary intervention was directly based on the exclusion of animal flesh foods. However, the short intervention period, relatively small sample size, and emphasis on mood rather than clinically diagnosed depression limit the extent to which conclusions can be drawn regarding long-term depressive outcomes (Beezhold & Johnston, 2012).

Agarwal et al. (2015) investigated the effects of a plant-based nutrition intervention in a multicenter corporate environment and evaluated changes in depression, anxiety, and work-related outcomes. The intervention was associated with improvements in measures of depression and anxiety, suggesting that plant-based dietary interventions may contribute to better psychological outcomes among adults in workplace settings (Agarwal et al., 2015). Nevertheless, these findings

should be interpreted with caution, as results obtained from workplace populations and mood-related measures cannot necessarily be generalized to individuals with clinically diagnosed major depressive disorder (Agarwal et al., 2015; Jain et al., 2022).

Additional indirect evidence has explored the effects of vegetarian dietary interventions on psychological outcomes in specific clinical populations (Kahleova et al., 2013). Kahleova et al. (2013) evaluated a vegetarian dietary intervention among individuals with type 2 diabetes and reported improvements in measures of mood and quality of life. However, because the participants had a metabolic disorder and depression was not the primary outcome of the study, the findings cannot be directly extrapolated to the prevention or treatment of depression (Jain et al., 2022; Kahleova et al., 2013).

Systematic reviews indicate that the current evidence examining vegetarian, vegan, and plant-based diets in relation to mental health outcomes remains limited and heterogeneous (Iguacel et al., 2021; Medawar et al., 2019). Medawar et al. (2019) reviewed the available literature on plant-based diets and brain-related outcomes, emphasizing the need for further research to better understand the relationship between plant-based dietary interventions and mental health. Likewise, Iguacel et al. (2021) concluded that most evidence linking vegetarian and vegan diets with mental health outcomes is derived from observational studies rather than randomized controlled trials.

Overall, the current clinical evidence indicates that plant-based dietary interventions may offer potential benefits for mood-related outcomes; however, the available data remain insufficient to support vegetarian or vegan diets as established strategies for the prevention or treatment of clinical depression (Agarwal et al., 2015; Beezhold & Johnston, 2012; Jain et al., 2022). Consequently, further randomized controlled trials specifically designed to evaluate depressive symptoms or clinically diagnosed depression as primary outcomes are needed to determine whether plant-based dietary interventions can play a direct role in the prevention or management of depression (Jain et al., 2022; Medawar et al., 2019).

4.5 Possible Biological Mechanisms

The potential association between plant-based dietary patterns and depressive outcomes may be influenced by several characteristics of these diets, including a higher intake of fiber-rich foods, increased exposure to plant-derived bioactive compounds, and differences in nutrient availability compared with other dietary patterns (Medawar et al., 2019). However, current evidence does not

establish a direct causal relationship between plant-based diets and depression, and the proposed mechanisms are largely based on the biological effects of dietary components commonly present in these eating patterns (Jain et al., 2022; Medawar et al., 2019).

One defining characteristic of plant-based dietary patterns is the increased consumption of a wide variety of plant foods that provide dietary fiber and substrates involved in microbial metabolism (Berding et al., 2021; Tomova et al., 2019). Studies comparing vegetarian, vegan, and omnivorous dietary patterns have suggested that differences in habitual dietary intake may contribute to variations in gut microbial composition and diversity (Tomova et al., 2019; Wong et al., 2018).

Plant-derived dietary fibers can be fermented by intestinal microorganisms, resulting in the production of short-chain fatty acids that have been studied for their potential roles in metabolic and neurobiological processes (Berding et al., 2021; Dalile et al., 2019). Nevertheless, direct evidence demonstrating that diet-induced changes in the gut microbiota lead to reductions in depressive symptoms remains limited (Berding et al., 2021; Medawar et al., 2019).

Another notable feature of many plant-based dietary patterns is the greater intake of foods rich in phytochemicals, including polyphenols and other bioactive compounds naturally found in fruits, vegetables, legumes, and whole grains (Manach et al., 2004; Medawar et al., 2019). These compounds have been investigated for their potential roles in biological pathways related to oxidative balance and the regulation of inflammatory processes; however, their specific contribution to depression-related outcomes within the context of plant-based diets has not yet been clearly established (Cory et al., 2018; Medawar et al., 2019).

The quality of plant-based food choices may also play an important role in determining their health-related effects, as not all plant-derived dietary patterns possess the same nutritional characteristics (Satija et al., 2017). Dietary patterns centered on minimally processed plant foods may offer substantially different nutritional profiles compared with plant-based diets that contain higher amounts of refined grains and highly processed products (Satija et al., 2017). This distinction may partly explain why studies examining different forms of plant-based dietary patterns have reported varying associations with depressive symptoms (Lee et al., 2021).

In addition to potentially beneficial dietary components, the relationship between plant-based diets and mental health may be influenced by nutrients that require particular attention when animal-derived foods are reduced or excluded (Bakaloudi et al., 2021; Iguacel et al., 2021). Vitamin B12 is one of the nutrients most frequently discussed in relation to vegan diets, as inadequate intake

may occur in the absence of fortified foods or supplementation, and this vitamin plays an important role in normal neurological function (Bakaloudi et al., 2021; O'Leary & Samman, 2010).

Long-chain omega-3 fatty acids represent another nutritional consideration in the assessment of plant-based diets because of differences in nutrient availability and their potential involvement in brain-related functions (Bakaloudi et al., 2021; Larrieu & Layé, 2018). Diets that exclude fish and seafood typically provide lower direct sources of EPA and DHA, although the extent to which these differences influence depressive outcomes among individuals following plant-based dietary patterns remains to be fully clarified (Bakaloudi et al., 2021; Iguacel et al., 2021).

Overall, the potential biological association between plant-based dietary patterns and depression is likely influenced by a combination of beneficial dietary components supplied by high-quality plant foods and the avoidance of potential nutritional deficiencies (Bakaloudi et al., 2021; Medawar et al., 2019). Current evidence indicates that the quality of the diet may be a more important determinant than simply categorizing dietary patterns according to the inclusion or exclusion of animal-derived foods (Lee et al., 2021; Satija et al., 2017).

4.6 Limitations of Current Evidence

Although the body of research examining plant-based dietary patterns and depression has grown considerably in recent years, several limitations continue to complicate the interpretation of current findings (Iguacel et al., 2021; Jain et al., 2022). The available evidence remains heterogeneous, with studies reporting varying associations between plant-based dietary patterns and depressive outcomes across different populations (Iguacel et al., 2021; Ocklenburg & Borawski, 2021).

One of the main limitations relates to the lack of consistency in the definition and classification of plant-based diets across studies (Iguacel et al., 2021). Some investigations classify participants simply as vegetarian, vegan, or omnivorous, whereas others assess adherence to plant-based dietary patterns by incorporating measures of dietary quality (Iguacel et al., 2021; Lee et al., 2021). These methodological differences make direct comparisons between studies challenging, as individuals assigned to the same dietary category may in fact follow substantially different dietary practices (Iguacel et al., 2021; Lee et al., 2021).

Differences in the characteristics of individuals following plant-based diets represent an important consideration when interpreting associations between these dietary patterns and depression (Jain et al., 2022). Individuals who follow vegetarian or vegan dietary patterns may differ from

omnivorous populations in a range of lifestyle, socioeconomic, and health-related characteristics that can independently affect mental health outcomes (Jain et al., 2022; Storz & Ronco, 2023). Psychological and personal motivations underlying the adoption of plant-based diets may further complicate the interpretation of associations between these dietary patterns and mental health outcomes (Iguacel et al., 2021; Rosenfeld, 2018). While some individuals choose plant-based diets primarily for health-related reasons, others may adopt them because of ethical, environmental, or personal considerations, which may be linked to distinct behavioral and psychological characteristics (Rosenfeld, 2018).

Another challenge is that classifying individuals as vegetarian or vegan does not necessarily capture the overall nutritional quality of their diets (Lee et al., 2021; Satija et al., 2017). Emerging evidence suggests that distinguishing between healthy and unhealthy plant-based dietary patterns may provide more meaningful insights than focusing solely on the exclusion of animal-derived foods (Lee et al., 2021; Satija et al., 2017). This distinction may help explain some of the inconsistencies observed across studies reporting different associations between plant-based diets and depressive symptoms (Jain et al., 2022; Lee et al., 2021).

Clinical evidence represents an additional limitation, as randomized controlled trials specifically designed to investigate plant-based dietary interventions and depression-related outcomes remain scarce (Iguacel et al., 2021; Medawar et al., 2019). Further intervention studies using depressive symptoms or clinically diagnosed depression as primary outcomes are needed to determine whether plant-based dietary modifications exert a direct effect on the prevention or management of depression (Jain et al., 2022; Medawar et al., 2019).

Overall, current evidence indicates that the relationship between plant-based dietary patterns and depression is complex and influenced by multiple factors, including dietary quality and individual characteristics (Iguacel et al., 2021; Jain et al., 2022; Lee et al., 2021). Future research should prioritize approaches that clearly distinguish between different forms and levels of quality within plant-based dietary patterns (Jain et al., 2022; Lee et al., 2021).

CHAPTER 5

DISCUSSION

5.1 Summary and Interpretation of Main Findings

The findings reviewed in this thesis suggest that the relationship between diet and depression is best understood by looking at overall dietary patterns rather than focusing solely on individual nutrients or specific food groups. Across the available literature, dietary patterns that emphasize minimally processed and nutrient-rich foods are generally associated with better depressive outcomes, while dietary patterns characterized by a high intake of ultra-processed and lower-quality foods tend to be linked with poorer outcomes (Lai et al., 2014; Li et al., 2017; Marx et al., 2017). These findings reflect the broader shift within nutritional psychiatry away from studying isolated nutrients and toward examining whole dietary patterns, which provide a more realistic representation of how people eat in everyday life (Hu, 2002; Lopresti et al., 2013; Marx et al., 2017).

A notable finding emerging from the reviewed evidence is that the Mediterranean diet has shown the most consistent associations with favorable depression-related outcomes across the available literature (Jacka et al., 2017; Lassale et al., 2019; Molendijk et al., 2018). This may be because the Mediterranean dietary pattern incorporates several characteristics that are considered beneficial for mental health, including high overall diet quality, a diverse range of nutrients, and lower inflammatory potential (Lassale et al., 2019; Marx et al., 2021). At the same time, it is important to acknowledge that the strength of the evidence may also be influenced by methodological factors (Lassale et al., 2019; Molendijk et al., 2018). Compared with other dietary patterns, the Mediterranean diet has received considerably more research attention, is supported by well-established adherence measures (Trichopoulou et al., 2003), and has been examined through both observational studies and intervention trials (Jacka et al., 2017; Lassale et al., 2019).

In contrast, Western dietary patterns are more consistently associated with unfavorable depressive outcomes. Rather than indicating that any single component of the Western diet directly contributes to depression, the available evidence suggests that the overall dietary pattern may be more important (Hu, 2002; Marx et al., 2021). High consumption of ultra-processed foods, low intake of fiber-rich foods, and poorer overall diet quality often occur together, making it difficult to determine the specific contribution of each component independently (Hu, 2002; Lane et al.,

2022). As a result, the relationship between Western dietary patterns and depression is likely influenced by the combined effects of multiple dietary and lifestyle factors rather than by a single nutritional exposure alone (Marx et al., 2021)

The interpretation of plant-based dietary patterns is somewhat more challenging. In contrast to the Mediterranean diet, plant-based diets encompass a broad and diverse range of eating patterns that can differ considerably in their nutritional composition (Hemler & Hu, 2019; Satija et al., 2017). This diversity may help explain why studies comparing vegetarian and vegan diets with omnivorous diets have produced mixed and sometimes conflicting findings (Iguacel et al., 2021; Jain et al., 2022). Recent research has increasingly highlighted the distinction between healthy and unhealthy plant-based dietary patterns, suggesting that the nutritional quality of plant foods consumed may play a more important role than simply reducing or excluding animal-derived products from the diet (Lee et al., 2021; Satija et al., 2017).

Overall, the comparison of different dietary patterns indicates that the association between diet and depression is unlikely to be explained by a straightforward categorization of diets as either beneficial or harmful (Marx et al., 2021; Molendijk et al., 2018). Rather, factors such as overall dietary quality, nutritional composition, and balance appear to be more important in understanding this relationship (Hu, 2002; Marx et al., 2017). At the same time, it is essential to recognize that depression is a complex and multifactorial condition shaped by a combination of biological, psychological, behavioral, and social influences. For this reason, diet should be viewed as one potentially important contributing factor within a broader framework of determinants, rather than as an independent predictor of mental health outcomes (Firth et al., 2020; Marx et al., 2021).

5.2 Comparison between Dietary Patterns

The comparison of Mediterranean, Western, and plant-based dietary patterns suggests that their differing associations with depression may be influenced more by overall dietary quality than by the specific dietary label assigned to them. While these dietary patterns vary considerably in terms of their composition, current evidence indicates that factors such as the degree of food processing, nutrient density, and dietary variety may play a particularly important role in shaping their relationship with depressive outcomes (Marx et al., 2017, 2021).

One of the most evident contrasts is observed between Mediterranean and Western dietary patterns. These two dietary approaches differ substantially in their fundamental characteristics,

with the Mediterranean diet placing greater emphasis on minimally processed foods and a varied intake of nutrient-rich foods, whereas Western dietary patterns are typically characterized by a higher consumption of ultra-processed and energy-dense products (Martínez-González et al., 2019; Monteiro et al., 2019). Such differences may help explain why these dietary patterns are generally associated with opposing depressive outcomes in epidemiological studies, with Mediterranean diets tending to show more favorable associations and Western diets showing less favorable ones (Lassale et al., 2019; Li et al., 2017).The main nutritional characteristics distinguishing Mediterranean, Western, and plant-based dietary patterns are summarized in Figure 3.

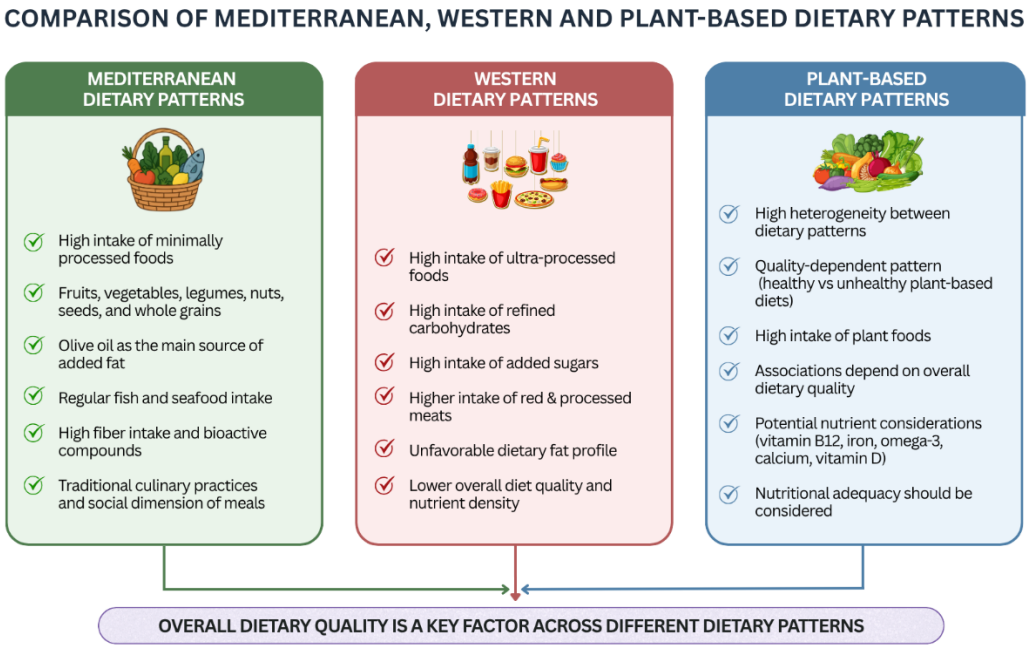

Figure 3. Comparative overview of the main characteristics of Mediterranean, Western, and plant-based dietary patterns discussed in relation to depression.

However, understanding these differences requires examining the overall dietary pattern rather than concentrating solely on individual foods or nutrients (Hu, 2002; Jacobs & Tapsell, 2013). For instance, the potential benefits linked to the Mediterranean diet are unlikely to be attributable to a single component, such as olive oil, fish, or vegetables in isolation. Instead, these benefits may arise from the combined and interactive effects of a variety of foods and nutrients that are consumed together within the context of a broader dietary pattern (Hu, 2002; Jacobs & Tapsell,

2013). Likewise, the associations observed between Western dietary patterns and depression are unlikely to be driven by one specific dietary element, such as sugar or saturated fat alone. Rather, they may reflect the cumulative influence of several dietary characteristics, including a high intake of ultra-processed foods, lower nutrient density, and a reduced consumption of nutrient-rich foods (Hu, 2002; Lane et al., 2022).

This perspective is particularly relevant because dietary factors rarely occur in isolation (Hu, 2002; Jacobs & Tapsell, 2013). Individuals who consume larger amounts of ultra-processed foods often have lower intakes of fruits, vegetables, whole grains, and other nutrient-dense foods. As a result, it becomes difficult to determine whether unfavorable associations are driven by the presence of less healthy dietary components, the lack of beneficial ones, or the overall dietary pattern itself (Hu, 2002; Lane et al., 2022). For this reason, the evaluation of dietary patterns offers a more comprehensive and realistic framework for understanding the relationship between diet and depression than the examination of individual nutrients alone (Marx et al., 2017).

The comparison between Mediterranean and plant-based dietary patterns further highlights the importance of considering dietary quality when examining associations with depression (Hemler & Hu, 2019; Satija et al., 2017). These dietary approaches share several common features, particularly when plant-based diets are centered on whole and minimally processed foods (Martínez-González et al., 2019; Medawar et al., 2019). Both patterns are often characterized by a high intake of vegetables, fruits, legumes, whole grains, nuts, dietary fiber, and various bioactive compounds that have been explored for their potential role in biological mechanisms related to mental health (Marx et al., 2021; Medawar et al., 2019).

Despite these shared characteristics, the evidence supporting plant-based diets remains less consistent than that observed for the Mediterranean diet (Iguacel et al., 2021; Jain et al., 2022). A possible reason for this inconsistency is the broad nature of the term “plant-based diet,” which encompasses a wide variety of eating patterns (Hemler & Hu, 2019; Satija et al., 2017). Some plant-based diets are predominantly composed of nutrient-dense whole foods, whereas others may include larger amounts of refined grains, added sugars, and highly processed plant-based products (Hemler & Hu, 2019; Satija et al., 2017). Consequently, individuals who are both categorized as following plant-based diets may, in reality, have markedly different dietary habits and nutritional exposures (Iguacel et al., 2021; Satija et al., 2017).

This distinction highlights an important limitation of categorizing diets solely based on the exclusion of certain foods (Hemler & Hu, 2019; Satija et al., 2017). Eliminating animal-derived foods from the diet does not necessarily result in a high-quality dietary pattern, just as including animal products does not automatically make a diet unhealthy (Hemler & Hu, 2019; Satija et al., 2017). Increasingly, the evidence suggests that the nutritional quality of the foods consumed may be a more informative indicator than broad dietary classifications alone (Lee et al., 2021).

Overall, findings from studies investigating Mediterranean, Western, and plant-based dietary patterns indicate that diet quality plays a key role in understanding their associations with depression (Marx et al., 2017, 2021). Dietary patterns that emphasize minimally processed foods, provide a diverse range of nutrients, and support adequate nutrient intake generally appear to be associated with more favorable depressive outcomes. In contrast, dietary patterns characterized by lower nutritional quality tend to be associated with less favorable outcomes (Lassale et al., 2019; Li et al., 2017). However, these associations should be interpreted with caution, as they remain subject to methodological limitations and do not demonstrate that dietary patterns alone are responsible for determining the risk of depression (Molendijk et al., 2018).

5.3 Integration of Biological Mechanisms

The biological mechanisms examined throughout this thesis indicate that the association between dietary patterns and depression is unlikely to be explained by a single underlying pathway. Rather, current evidence suggests that diet may influence multiple interconnected biological systems that are involved in mental health, including inflammation, oxidative stress, gut microbiota composition, metabolic regulation, neurotransmitter function, and neuroplasticity (Berk et al., 2013; Marx et al., 2021).

A key observation emerging from the comparison of different dietary patterns is that many of these proposed mechanisms are shared across diets, although their effects may vary according to overall dietary quality. For example, Mediterranean dietary patterns and high-quality plant-based diets have several features in common, particularly a higher intake of fiber-rich foods and bioactive compounds. These dietary characteristics may contribute to biological processes related to inflammatory control, oxidative balance, and the regulation of gut microbiota composition (Marx et al., 2021; Medawar et al., 2019; Satija et al., 2017). By contrast, Western dietary patterns have

been linked to unfavorable changes in many of the same biological systems, including increased inflammatory activity and poorer metabolic functioning (Malesza et al., 2021; Marx et al., 2021). Inflammation is one of the most widely discussed mechanisms linking dietary patterns to depression. Rather than functioning as a separate biological process, inflammatory activity appears to interact with a range of physiological systems that are involved in the regulation of mood and mental health (Marx et al., 2021; Miller & Raison, 2016). This interconnected nature may help explain why dietary patterns that influence inflammatory processes could potentially affect several depression-related pathways at the same time. Nevertheless, although studies have reported associations between the inflammatory potential of diets and depressive outcomes, the direction and magnitude of these relationships remain difficult to establish. This is partly because inflammation may act not only as a contributing factor to depression but also as a consequence of depressive symptoms themselves (Miller & Raison, 2016; Molendijk et al., 2018).

The gut microbiota provides another example of the complex interplay between diet and mental health. Among the many environmental factors that shape microbial composition, dietary patterns are considered particularly influential, with differences in food quality and fiber intake potentially contributing to variations in gut microbial communities (Berding et al., 2021; Tomova et al., 2019). However, current evidence does not conclusively demonstrate that dietary changes affecting the gut microbiota directly lead to improvements or deterioration in depressive symptoms. Instead, the gut–brain axis is best understood as one potential mechanism within a broader and highly interconnected network of biological processes involved in mental health (Berding et al., 2021; Cheung et al., 2019).

Similarly, oxidative stress and metabolic dysfunction have been proposed as potential mechanisms underlying the relationship between dietary patterns and depression. Dietary patterns rich in minimally processed foods may provide a wide range of nutrients and bioactive compounds that support antioxidant defenses and metabolic health, whereas lower-quality dietary patterns are more often associated with biological conditions linked to oxidative imbalance and metabolic dysregulation (Marx et al., 2021; Medawar et al., 2019). However, these mechanisms do not operate independently of other lifestyle factors. Variables such as physical activity, sleep quality, and body composition are also closely related to both metabolic and mental health outcomes (Firth et al., 2020), making it difficult to determine the specific contribution of diet alone (Firth et al., 2020; Marx et al., 2021).

The interpretation of these biological pathways is further complicated by the bidirectional nature of depression. While dietary patterns may influence biological processes that are relevant to mental health, depression itself can affect behaviors such as appetite regulation, motivation, food selection, and physical activity, which may subsequently alter physiological functioning (Lopresti et al., 2013; Molendijk et al., 2018). As a result, the biological relationship between diet and depression should not be viewed as a simple cause-and-effect process operating in a single direction (Molendijk et al., 2018).

Overall, the current evidence suggests that dietary patterns may influence depression-related outcomes through a range of interconnected biological mechanisms rather than through the effects of individual nutrients in isolation (Marx et al., 2021). This reinforces the importance of studying whole dietary patterns, as they provide a more comprehensive understanding of diet–depression relationships than the examination of single nutrients alone (Hu, 2002; Marx et al., 2017). Nevertheless, additional research is needed to better understand the extent to which these biological mechanisms contribute to depressive outcomes in humans and whether long-term dietary changes can meaningfully modify these pathways over time (Marx et al., 2021; Molendijk et al., 2018).

5.4 Methodological Considerations and Limitations of Current Evidence

Although the current body of evidence points to meaningful associations between dietary patterns and depressive outcomes, several methodological limitations should be taken into account when interpreting these findings (Lassale et al., 2019; Molendijk et al., 2018). Nutritional psychiatry remains an emerging area of research, and determining whether diet directly influences depression continues to be a complex task. This challenge largely reflects the multifaceted nature of both dietary behaviors and mental health disorders, which are influenced by a wide range of interacting factors (Marx et al., 2021; Molendijk et al., 2018).

One of the main limitations of existing literature is its heavy reliance on observational research. A large proportion of studies examining Mediterranean, Western, and plant-based dietary patterns are based on cohort or cross-sectional designs, which are useful for identifying associations but are limited in their ability to establish whether dietary patterns directly affect the risk of depression (Lassale et al., 2019; Molendijk et al., 2018). While prospective studies offer stronger evidence by assessing dietary exposure before the development of depressive outcomes, they are still

susceptible to residual confounding and various forms of bias that may influence the observed relationships (Molendijk et al., 2018).

Another important methodological concern is the potential for reverse causality. Depression can itself affect several behaviors related to food intake, including appetite, motivation, meal preparation, and dietary choices (Lopresti et al., 2013; Molendijk et al., 2018). As a result, the poorer dietary patterns often observed among individuals experiencing depressive symptoms may, in some cases, be a consequence of depression rather than solely a factor contributing to it (Molendijk et al., 2018). This limitation is particularly relevant in cross-sectional studies, where dietary habits and depressive symptoms are assessed at the same point in time, making it difficult to determine which factor occurred first and to establish clear temporal relationships (Molendijk et al., 2018).

Residual confounding is another important factor that must be considered when interpreting the available evidence. Dietary behaviors are closely intertwined with a variety of lifestyle and socioeconomic factors that can also affect mental health outcomes (Firth et al., 2020; Molendijk et al., 2018). For instance, individuals who adhere to healthier dietary patterns often differ from others in terms of physical activity, smoking and alcohol consumption, access to healthcare services, and socioeconomic status (Firth et al., 2020; Lassale et al., 2019). Although researchers attempt to account for these variables through statistical adjustment, it remains difficult to completely separate the specific effects of diet from the influence of other related factors in observational studies (Lassale et al., 2019; Molendijk et al., 2018)

Another methodological challenge relates to the assessment of dietary intake. Most large-scale studies in nutrition research depend on self-reported measures, such as food frequency questionnaires, which are vulnerable to recall bias and reporting inaccuracies (Shim et al., 2014). Errors in reporting food consumption can affect estimates of adherence to particular dietary patterns and may contribute to inconsistencies across studies (Shim et al., 2014). In addition, variations in dietary scoring methods and the criteria used to define dietary patterns can make comparisons between studies and populations more complex (Lassale et al., 2019; Newby & Tucker, 2004).

The classification and definition of dietary patterns present further methodological difficulties. Although the Mediterranean diet is supported by relatively well-established adherence indices, there is still variation in the way adherence is assessed across different studies (Davis et al., 2015;

Trichopoulou et al., 2003). Western dietary patterns are frequently identified using population-specific statistical methods, meaning that a pattern labeled as "Western" in one population may not reflect exactly the same dietary exposure in another (Newby & Tucker, 2004). Likewise, plant-based diets encompass a wide spectrum of dietary behaviors, ranging from nutrient-dense eating patterns based on whole foods to patterns that include larger amounts of processed plant-derived products. This heterogeneity may partly account for the inconsistent findings reported in studies investigating plant-based diets and depression (Iguacel et al., 2021; Satija et al., 2017).

Variations in the methods used to assess depression also contribute to the heterogeneity observed across the literature. While some studies focus on clinically diagnosed major depressive disorder, others rely on self-reported instruments designed to measure depressive symptoms (Lai et al., 2014; Lassale et al., 2019). These differences in assessment approaches may affect the strength and nature of the associations reported, making it more challenging to compare findings across studies and draw consistent conclusions (Lai et al., 2014; Lassale et al., 2019).

Although randomized controlled trials are generally considered to provide stronger evidence than observational studies, dietary intervention research is not without its own methodological limitations (Jacka et al., 2017; Opie et al., 2018). Unlike pharmacological studies, nutrition interventions are difficult to blind because participants are typically aware of the dietary changes they are expected to follow (Opie et al., 2018). Furthermore, dietary interventions often include additional components such as nutritional counseling, behavioral guidance, and more frequent contact with researchers. As a result, it can be difficult to determine whether observed outcomes are attributable specifically to dietary modifications or to the wider supportive environment created by the intervention itself (Opie et al., 2018).

Another limitation of the current evidence base is that many dietary intervention studies involve relatively small participant samples and short follow-up periods (Jacka et al., 2017; Parletta et al., 2019). Given that depression is a complex, long-term condition influenced by a combination of biological, psychological, and environmental factors, longer-term investigations are needed to determine whether dietary changes can produce lasting improvements in mental health outcomes (Firth et al., 2020; Marx et al., 2021).

Overall, although the existing literature provides support for an association between dietary patterns and depression, these findings should be interpreted in light of the methodological limitations discussed above (Marx et al., 2021; Molendijk et al., 2018). Future research would

benefit from the use of more standardized dietary assessment methods, larger randomized controlled trials, extended follow-up durations, and clearer classification of dietary patterns. Such improvements may help provide a more comprehensive understanding of the role that diet could play in the prevention and management of depression (Marx et al., 2021; Molendijk et al., 2018).

5.5 Implications and Future Research Directions

The findings presented in this thesis suggest that dietary patterns may be considered one modifiable component within a broader framework for promoting mental health. At the same time, the relationship between diet and depression should be understood within the context of the multifactorial nature of depressive disorders, which are shaped by the interaction of biological, psychological, social, and lifestyle-related factors (Firth et al., 2020; Marx et al., 2021). Consequently, dietary interventions should not be viewed as a substitute for established treatments for depression, but rather as a complementary approach that may support overall mental well-being (Firth et al., 2020).

An important implication arising from the current evidence is the emphasis on overall dietary quality rather than individual foods or specific nutrients. Research examining different dietary patterns suggests that eating habits characterized by minimally processed foods, a varied diet, and adequate nutrient intake may have greater relevance for mental health outcomes than focusing on isolated dietary components alone (Hu, 2002; Lassale et al., 2019; Marx et al., 2017). This perspective acknowledges the complexity of human nutrition, where foods and nutrients are consumed in combination and may exert their effects through multiple interconnected biological pathways (Jacobs & Tapsell, 2013).

From a public health perspective, dietary recommendations intended to support mental health may be more effective when they focus on broad principles of healthy eating rather than endorsing a single dietary pattern. The evidence reviewed in this thesis indicates that different dietary approaches can share common beneficial features when they emphasize high-quality food choices. For instance, although Mediterranean and carefully planned plant-based diets differ in several respects, both can promote the consumption of minimally processed foods, fiber-rich ingredients, and a diverse range of nutrients (Martínez-González et al., 2019; Medawar et al., 2019; Melina et al., 2016).

At the same time, further research is needed to better understand why some dietary patterns demonstrate more consistent associations with depressive outcomes than others. The Mediterranean diet currently has the strongest body of evidence, supported by findings from both observational research and dietary intervention studies. In contrast, evidence regarding plant-based dietary patterns remains more variable, highlighting the need for additional research focused on dietary quality, nutrient adequacy, and the long-term implications for mental health (Iguacel et al., 2021; Jain et al., 2022; Lassale et al., 2019; Medawar et al., 2019).

Future investigations should also seek to address several methodological challenges that continue to affect research in nutritional psychiatry. Greater emphasis should be placed on intervention studies specifically designed to assess depressive outcomes, including the long-term sustainability of dietary changes and the factors that may influence individual responses to dietary interventions (Marx et al., 2021; Molendijk et al., 2018). Furthermore, the development of more accurate dietary assessment tools and more consistent definitions of dietary patterns would improve comparability across studies and strengthen the overall evidence base (Lassale et al., 2019).

Another important area for future research is the identification of population groups that may derive the greatest benefit from dietary interventions. Depression is a highly heterogeneous condition, and individuals differ in terms of their biological profiles, lifestyle behaviors, socioeconomic circumstances, and nutritional status (Marx et al., 2021). Gaining a deeper understanding of these individual differences may help explain why dietary modifications appear to be more effective for some people than for others (Marx et al., 2021).

In addition, future studies should further investigate how changes in the biological mechanisms proposed to link diet and depression translate into meaningful clinical outcomes. While inflammation, oxidative stress, gut microbiota composition, metabolic regulation, and neuroplasticity represent plausible biological pathways, more evidence is needed to establish the extent to which modifications in these systems directly contribute to reductions in depressive symptoms following dietary interventions (Berk et al., 2013; Marx et al., 2021).

In conclusion, the current body of evidence supports the view that dietary patterns may represent one important factor associated with depression, while simultaneously emphasizing the complexity of this relationship. A more comprehensive understanding will require future research that integrates nutritional, biological, psychological, and lifestyle perspectives, allowing a clearer

evaluation of the ways in which dietary habits may influence mental health outcomes (Firth et al., 2020; Marx et al., 2021).

CHAPTER 6

CONCLUSIONS

Depression is a complex and multifactorial disorder that arises from the interaction of biological, psychological, social, and lifestyle-related factors. In recent years, growing interest has focused on the potential role of modifiable lifestyle factors, particularly diet, in influencing mental health outcomes. This thesis reviewed the current evidence on the relationship between dietary patterns and depression, with particular attention to Mediterranean, Western, and plant-based dietary patterns.

Overall, the evidence examined in this thesis suggests that dietary quality is a key consideration when evaluating the association between dietary patterns and depression. Rather than concentrating solely on individual nutrients, specific foods, or broad dietary classifications, current research emphasizes the importance of considering dietary patterns in their entirety. Dietary patterns characterized by higher nutritional quality are generally associated with more favorable depressive outcomes, whereas patterns of lower overall quality tend to show less favorable associations (Lassale et al., 2019; Marx et al., 2021). The comparison of Mediterranean, Western, and plant-based dietary patterns further demonstrates that dietary labels alone do not adequately explain their relationship with depression. Instead, greater attention should be given to the overall quality, composition, and context of dietary habits. This perspective is particularly relevant because different dietary approaches may share beneficial features while also presenting distinct limitations. As a result, examining dietary patterns within their broader context provides a more meaningful understanding of their potential influence on mental health.

The findings reviewed in this thesis also suggest that the relationship between dietary patterns and depression cannot be attributed to a single biological mechanism. Rather, diet may interact with multiple interconnected biological pathways that are involved in mental health and emotional well-being. Nevertheless, these biological processes operate within a broader framework of psychological, environmental, lifestyle, and physiological influences, highlighting the complexity of the relationship between diet and depression (Berk et al., 2013; Marx et al., 2021).

Despite the growing body of evidence linking dietary patterns with depressive outcomes, important limitations remain. Methodological differences between studies, along with the potential influence of residual confounding and reverse causality, should be carefully considered when interpreting

the existing literature (Molendijk et al., 2018). Future research should focus not only on determining whether dietary patterns affect depression-related outcomes, but also on identifying which aspects of diet are most influential, which groups of individuals are most likely to benefit, and how dietary changes interact with other lifestyle factors over time.

In conclusion, diet should be viewed as one contributing factor within the broader context of mental health rather than as an independent determinant of depression. The findings of this thesis support moving beyond the classification of dietary patterns as simply beneficial or harmful and toward a more nuanced understanding that considers dietary quality, context, and individual variability. Integrating nutritional research with biological, psychological, and lifestyle perspectives may ultimately provide a more comprehensive understanding of how dietary patterns contribute to mental health outcomes.

BIBLIOGRAPHY

Adjibade, M., Julia, C., Allès, B., Touvier, M., Lemogne, C., Srour, B., Hercberg, S., Galan, P., Assmann, K. E., & Kesse-Guyot, E. (2019). Prospective association between ultra-processed food consumption and incident depressive symptoms in the French NutriNet-Santé cohort. *BMC Medicine*, *17*(1), 78. https://doi.org/10.1186/s12916-019-1312-y

Agarwal, U., Mishra, S., Xu, J., Levin, S., Gonzales, J., & Barnard, N. D. (2015). A multicenter randomized controlled trial of a nutrition intervention program in a multiethnic adult population in the corporate setting reduces depression and anxiety and improves quality of life: The GEICO study. *American Journal of Health Promotion: AJHP*, *29*(4), 245–254. https://doi.org/10.4278/ajhp.130218-QUAN-72

Akbaraly, T. N., Brunner, E. J., Ferrie, J. E., Marmot, M. G., Kivimaki, M., & Singh-Manoux, A. (2009). Dietary pattern and depressive symptoms in middle age. *The British Journal of Psychiatry: The Journal of Mental Science*, *195*(5), 408–413. https://doi.org/10.1192/bjp.bp.108.058925

Al-Khatib, Y., Akhtar, M. A., Kanawati, M. A., Mucheke, R., Mahfouz, M., & Al-Nufoury, M. (n.d.). Depression and Metabolic Syndrome: A Narrative Review. *Cureus*, *14*(2), e22153. https://doi.org/10.7759/cureus.22153

Arnett, J. J., Žukauskienė, R., & Sugimura, K. (2014). The new life stage of emerging adulthood at ages 18-29 years: Implications for mental health. *The Lancet. Psychiatry*, *1*(7), 569–576. https://doi.org/10.1016/S2215-0366(14)00080-7

Arnone, D., Saraykar, S., Salem, H., Teixeira, A. L., Dantzer, R., & Selvaraj, S. (2018). Role of Kynurenine Pathway and its Metabolites in Mood Disorders: A Systematic Review and

Meta-Analysis of Clinical Studies. *Neuroscience and Biobehavioral Reviews*, *92*, 477–485. https://doi.org/10.1016/j.neubiorev.2018.05.031

Auerbach, R. P., Alonso, J., Axinn, W. G., Cuijpers, P., Ebert, D. D., Green, J. G., Hwang, I., Kessler, R. C., Liu, H., Mortier, P., Nock, M. K., Pinder-Amaker, S., Sampson, N. A., Aguilar-Gaxiola, S., Al-Hamzawi, A., Andrade, L. H., Benjet, C., Caldas-de-Almeida, J. M., Demyttenaere, K., … Bruffaerts, R. (2016). Mental disorders among college students in the World Health Organization World Mental Health Surveys. *Psychological Medicine*, *46*(14), 2955–2970. https://doi.org/10.1017/S0033291716001665

Bach-Faig, A., Berry, E. M., Lairon, D., Reguant, J., Trichopoulou, A., Dernini, S., Medina, F. X., Battino, M., Belahsen, R., Miranda, G., Serra-Majem, L., & Mediterranean Diet Foundation Expert Group. (2011). Mediterranean diet pyramid today. Science and cultural updates. *Public Health Nutrition*, *14*(12A), 2274–2284. https://doi.org/10.1017/S1368980011002515

Baden, M. Y., Liu, G., Satija, A., Li, Y., Sun, Q., Fung, T. T., Rimm, E. B., Willett, W. C., Hu, F. B., & Bhupathiraju, S. N. (2019). Changes in Plant-Based Diet Quality and Total and Cause-Specific Mortality. *Circulation*, *140*(12), 979–991. https://doi.org/10.1161/CIRCULATIONAHA.119.041014

Baglioni, C., Battagliese, G., Feige, B., Spiegelhalder, K., Nissen, C., Voderholzer, U., Lombardo, C., & Riemann, D. (2011). Insomnia as a predictor of depression: A meta-analytic evaluation of longitudinal epidemiological studies. *Journal of Affective Disorders*, *135*(1–3), 10–19. https://doi.org/10.1016/j.jad.2011.01.011

Bakaloudi, D. R., Halloran, A., Rippin, H. L., Oikonomidou, A. C., Dardavesis, T. I., Williams, J., Wickramasinghe, K., Breda, J., & Chourdakis, M. (2021). Intake and adequacy of the

vegan diet. A systematic review of the evidence. *Clinical Nutrition*, *40*(5), 3503–3521. https://doi.org/10.1016/j.clnu.2020.11.035

Bayes, J., Schloss, J., & Sibbritt, D. (2020). Effects of Polyphenols in a Mediterranean Diet on Symptoms of Depression: A Systematic Literature Review. *Advances in Nutrition*, *11*(3), 602–615. https://doi.org/10.1093/advances/nmz117

Bayes, J., Schloss, J., & Sibbritt, D. (2022). The effect of a Mediterranean diet on the symptoms of depression in young males (the "AMMEND: A Mediterranean Diet in MEN with Depression" study): a randomized controlled trial. *The American Journal of Clinical Nutrition*, *116*(2), 572–580. https://doi.org/10.1093/ajcn/nqac106

Beezhold, B. L., & Johnston, C. S. (2012). Restriction of meat, fish, and poultry in omnivores improves mood: A pilot randomized controlled trial. *Nutrition Journal*, *11*, 9. https://doi.org/10.1186/1475-2891-11-9

Bègue, L., & Shankland, R. (2022). Is vegetarianism related to anxiety and depression? A cross-sectional survey in a French sample. *Journal of Health, Population, and Nutrition*, *41*, 18. https://doi.org/10.1186/s41043-022-00300-2

Belmaker, R. H., & Agam, G. (2008). Major depressive disorder. *The New England Journal of Medicine*, *358*(1), 55–68. https://doi.org/10.1056/NEJMra073096

Berding, K., Vlckova, K., Marx, W., Schellekens, H., Stanton, C., Clarke, G., Jacka, F., Dinan, T. G., & Cryan, J. F. (2021). Diet and the Microbiota-Gut-Brain Axis: Sowing the Seeds of Good Mental Health. *Advances in Nutrition*, *12*(4), 1239–1285. https://doi.org/10.1093/advances/nmaa181

Berk, M., Williams, L. J., Jacka, F. N., O'Neil, A., Pasco, J. A., Moylan, S., Allen, N. B., Stuart, A. L., Hayley, A. C., Byrne, M. L., & Maes, M. (2013). So depression is an inflammatory

disease, but where does the inflammation come from? *BMC Medicine*, *11*, 200. https://doi.org/10.1186/1741-7015-11-200

Black, C. N., Bot, M., Scheffer, P. G., Cuijpers, P., & Penninx, B. W. J. H. (2015). Is depression associated with increased oxidative stress? A systematic review and meta-analysis. *Psychoneuroendocrinology*, *51*, 164–175. https://doi.org/10.1016/j.psyneuen.2014.09.025

Bonaccio, M., Cerletti, C., Iacoviello, L., & de gaetano, giovanni. (2015). Mediterranean Diet and Low-grade Subclinical Inflammation: The Moli-sani Study. *Endocrine*, *15*. https://doi.org/10.2174/1871530314666141020112146

Bonaccio, M., Di Castelnuovo, A., Pounis, G., Costanzo, S., Persichillo, M., Cerletti, C., Donati, M. B., de Gaetano, G., Iacoviello, L., & Moli-sani Study Investigators. (2017). High adherence to the Mediterranean diet is associated with cardiovascular protection in higher but not in lower socioeconomic groups: Prospective findings from the Moli-sani study. *International Journal of Epidemiology*, *46*(5), 1478–1487. https://doi.org/10.1093/ije/dyx145

Calder, P. C. (2015). Functional Roles of Fatty Acids and Their Effects on Human Health. *JPEN. Journal of Parenteral and Enteral Nutrition*, *39*(1 Suppl), 18S-32S. https://doi.org/10.1177/0148607115595980

Calder, P. C., Ahluwalia, N., Brouns, F., Buetler, T., Clement, K., Cunningham, K., Esposito, K., Jönsson, L. S., Kolb, H., Lansink, M., Marcos, A., Margioris, A., Matusheski, N., Nordmann, H., O'Brien, J., Pugliese, G., Rizkalla, S., Schalkwijk, C., Tuomilehto, J., … Winklhofer-Roob, B. M. (2011). Dietary factors and low-grade inflammation in relation to overweight and obesity. *The British Journal of Nutrition*, *106 Suppl 3*, S5-78. https://doi.org/10.1017/S0007114511005460

Casas, R., Sacanella, E., Urpí-Sardà, M., Chiva-Blanch, G., Ros, E., Martínez-González, M.-A., Covas, M.-I., Rosa Ma Lamuela-Raventos, Salas-Salvadó, J., Fiol, M., Arós, F., & Estruch, R. (2014). The effects of the mediterranean diet on biomarkers of vascular wall inflammation and plaque vulnerability in subjects with high risk for cardiovascular disease. A randomized trial. *PloS One*, *9*(6), e100084. https://doi.org/10.1371/journal.pone.0100084

Castrén, E., & Monteggia, L. M. (2021). Brain-Derived Neurotrophic Factor Signaling in Depression and Antidepressant Action. *Biological Psychiatry*, *90*(2), 128–136. https://doi.org/10.1016/j.biopsych.2021.05.008

Chen, G.-Q., Peng, C.-L., Lian, Y., Wang, B.-W., Chen, P.-Y., & Wang, G.-P. (2021). Association Between Dietary Inflammatory Index and Mental Health: A Systematic Review and Dose-Response Meta-Analysis. *Frontiers in Nutrition*, *8*, 662357. https://doi.org/10.3389/fnut.2021.662357

Cheung, S. G., Goldenthal, A. R., Uhlemann, A.-C., Mann, J. J., Miller, J. M., & Sublette, M. E. (2019). Systematic Review of Gut Microbiota and Major Depression. *Frontiers in Psychiatry*, *10*, 34. https://doi.org/10.3389/fpsyt.2019.00034

Clarys, P., Deliens, T., Huybrechts, I., Deriemaeker, P., Vanaelst, B., De Keyzer, W., Hebbelinck, M., & Mullie, P. (2014). Comparison of nutritional quality of the vegan, vegetarian, semi-vegetarian, pesco-vegetarian and omnivorous diet. *Nutrients*, *6*(3), 1318–1332. https://doi.org/10.3390/nu6031318

Clemente-Suárez, V. J., Beltrán-Velasco, A. I., Redondo-Flórez, L., Martín-Rodríguez, A., & Tornero-Aguilera, J. F. (2023). Global Impacts of Western Diet and Its Effects on

Metabolism and Health: A Narrative Review. *Nutrients*, *15*(12), 2749. https://doi.org/10.3390/nu15122749

Conn, V. S. (2010). Depressive Symptom Outcomes of Physical Activity Interventions: Meta-analysis Findings. *Annals of Behavioral Medicine : A Publication of the Society of Behavioral Medicine*, *39*(2), 128–138. https://doi.org/10.1007/s12160-010-9172-x

Cordain, L., Eaton, S. B., Sebastian, A., Mann, N., Lindeberg, S., Watkins, B. A., O'Keefe, J. H., & Brand-Miller, J. (2005). Origins and evolution of the Western diet: Health implications for the 21st century. *The American Journal of Clinical Nutrition*, *81*(2), 341–354. https://doi.org/10.1093/ajcn.81.2.341

Correia, A. S., Cardoso, A., & Vale, N. (2023). Oxidative Stress in Depression: The Link with the Stress Response, Neuroinflammation, Serotonin, Neurogenesis and Synaptic Plasticity. *Antioxidants*, *12*(2), 470. https://doi.org/10.3390/antiox12020470

Cory, H., Passarelli, S., Szeto, J., Tamez, M., & Mattei, J. (2018). The Role of Polyphenols in Human Health and Food Systems: A Mini-Review. *Frontiers in Nutrition*, *5*, 87. https://doi.org/10.3389/fnut.2018.00087

Craig, W. J., Mangels, A. R., & American Dietetic Association. (2009). Position of the American Dietetic Association: Vegetarian diets. *Journal of the American Dietetic Association*, *109*(7), 1266–1282. https://doi.org/10.1016/j.jada.2009.05.027

Dalile, B., Van Oudenhove, L., Vervliet, B., & Verbeke, K. (2019). The role of short-chain fatty acids in microbiota-gut-brain communication. *Nature Reviews. Gastroenterology & Hepatology*, *16*(8), 461–478. https://doi.org/10.1038/s41575-019-0157-3

Dash, S., Clarke, G., Berk, M., & Jacka, F. N. (2015). The gut microbiome and diet in psychiatry: Focus on depression. *Current Opinion in Psychiatry*, *28*(1), 1–6. https://doi.org/10.1097/YCO.0000000000000117

Davis, C., Bryan, J., Hodgson, J., & Murphy, K. (2015). Definition of the Mediterranean Diet; a Literature Review. *Nutrients*, *7*(11), 9139–9153. https://doi.org/10.3390/nu7115459

De Filippis, F., Pellegrini, N., Vannini, L., Jeffery, I. B., La Storia, A., Laghi, L., Serrazanetti, D. I., Di Cagno, R., Ferrocino, I., Lazzi, C., Turroni, S., Cocolin, L., Brigidi, P., Neviani, E., Gobbetti, M., O'Toole, P. W., & Ercolini, D. (2016). High-level adherence to a Mediterranean diet beneficially impacts the gut microbiota and associated metabolome. *Gut*, *65*(11), 1812–1821. https://doi.org/10.1136/gutjnl-2015-309957

Depressive disorder (depression). (n.d.). Retrieved May 24, 2026, from https://www.who.int/news-room/fact-sheets/detail/depression

Dinu, M., Abbate, R., Gensini, G. F., Casini, A., & Sofi, F. (2017). Vegetarian, vegan diets and multiple health outcomes: A systematic review with meta-analysis of observational studies. *Critical Reviews in Food Science and Nutrition*, *57*(17), 3640–3649. https://doi.org/10.1080/10408398.2016.1138447

Dinu, M., Pagliai, G., Casini, A., & Sofi, F. (2018). Mediterranean diet and multiple health outcomes: An umbrella review of meta-analyses of observational studies and randomised trials. *European Journal of Clinical Nutrition*, *72*(1), 30–43. https://doi.org/10.1038/ejcn.2017.58

Drewnowski, A., & Specter, S. E. (2004). Poverty and obesity: The role of energy density and energy costs. *The American Journal of Clinical Nutrition*, *79*(1), 6–16. https://doi.org/10.1093/ajcn/79.1.6

Duman, R. S., Aghajanian, G. K., Sanacora, G., & Krystal, J. H. (2016). Synaptic plasticity and depression: New insights from stress and rapid-acting antidepressants. *Nature Medicine*, *22*(3), 238–249. https://doi.org/10.1038/nm.4050

Estruch, R., Ros, E., Salas-Salvadó, J., Covas, M.-I., Corella, D., Arós, F., Gómez-Gracia, E., Ruiz-Gutiérrez, V., Fiol, M., Lapetra, J., Lamuela-Raventos, R. M., Serra-Majem, L., Pintó, X., Basora, J., Muñoz, M. A., Sorlí, J. V., Martínez, J. A., Fitó, M., Gea, A., … PREDIMED Study Investigators. (2018). Primary Prevention of Cardiovascular Disease with a Mediterranean Diet Supplemented with Extra-Virgin Olive Oil or Nuts. *The New England Journal of Medicine*, *378*(25), e34. https://doi.org/10.1056/NEJMoa1800389

Fazelian, S., Sadeghi, E., Firouzi, S., & Haghighatdoost, F. (2022). Adherence to the vegetarian diet may increase the risk of depression: A systematic review and meta-analysis of observational studies. *Nutrition Reviews*, *80*(2), 242–254. https://doi.org/10.1093/nutrit/nuab013

Felger, J. C., & Lotrich, F. E. (2013). Inflammatory Cytokines in Depression: Neurobiological Mechanisms and Therapeutic Implications. *Neuroscience*, *246*, 199–229. https://doi.org/10.1016/j.neuroscience.2013.04.060

Firth, J., Solmi, M., Wootton, R. E., Vancampfort, D., Schuch, F. B., Hoare, E., Gilbody, S., Torous, J., Teasdale, S. B., Jackson, S. E., Smith, L., Eaton, M., Jacka, F. N., Veronese, N., Marx, W., Ashdown-Franks, G., Siskind, D., Sarris, J., Rosenbaum, S., … Stubbs, B. (2020). A meta-review of "lifestyle psychiatry": The role of exercise, smoking, diet and sleep in the prevention and treatment of mental disorders. *World Psychiatry: Official Journal of the World Psychiatric Association*, *19*(3), 360–380. https://doi.org/10.1002/wps.20773

Fiske, A., Wetherell, J. L., & Gatz, M. (2009). Depression in older adults. *Annual Review of Clinical Psychology*, *5*, 363–389. https://doi.org/10.1146/annurev.clinpsy.032408.153621

Fluharty, M., Taylor, A. E., Grabski, M., & Munafò, M. R. (2017). The Association of Cigarette Smoking With Depression and Anxiety: A Systematic Review. *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco*, *19*(1), 3–13. https://doi.org/10.1093/ntr/ntw140

Foster, J. A., Rinaman, L., & Cryan, J. F. (2017). Stress & the gut-brain axis: Regulation by the microbiome. *Neurobiology of Stress*, *7*, 124–136. https://doi.org/10.1016/j.ynstr.2017.03.001

Fung, T. T., Hu, F. B., McCullough, M. L., Newby, P. K., Willett, W. C., & Holmes, M. D. (2006). Diet quality is associated with the risk of estrogen receptor-negative breast cancer in postmenopausal women. *The Journal of Nutrition*, *136*(2), 466–472. https://doi.org/10.1093/jn/136.2.466

Gangwisch, J. E., Hale, L., Garcia, L., Malaspina, D., Opler, M. G., Payne, M. E., Rossom, R. C., & Lane, D. (2015). High glycemic index diet as a risk factor for depression: Analyses from the Women's Health Initiative. *The American Journal of Clinical Nutrition*, *102*(2), 454–463. https://doi.org/10.3945/ajcn.114.103846

Gantenbein, K. V., & Kanaka-Gantenbein, C. (2021). Mediterranean Diet as an Antioxidant: The Impact on Metabolic Health and Overall Wellbeing. *Nutrients*, *13*(6), 1951. https://doi.org/10.3390/nu13061951

García-Montero, C., Fraile-Martínez, O., Gómez-Lahoz, A. M., Pekarek, L., Castellanos, A. J., Noguerales-Fraguas, F., Coca, S., Guijarro, L. G., García-Honduvilla, N., Asúnsolo, A., Sanchez-Trujillo, L., Lahera, G., Bujan, J., Monserrat, J., Álvarez-Mon, M., Álvarez-

Mon, M. A., & Ortega, M. A. (2021). Nutritional Components in Western Diet Versus Mediterranean Diet at the Gut Microbiota-Immune System Interplay. Implications for Health and Disease. *Nutrients*, *13*(2), 699. https://doi.org/10.3390/nu13020699

Gómez-Donoso, C., Sánchez-Villegas, A., Martínez-González, M. A., Gea, A., Mendonça, R. de D., Lahortiga-Ramos, F., & Bes-Rastrollo, M. (2020). Ultra-processed food consumption and the incidence of depression in a Mediterranean cohort: The SUN Project. *European Journal of Nutrition*, *59*(3), 1093–1103. https://doi.org/10.1007/s00394-019-01970-1

Gorzynik-Debicka, M., Przychodzen, P., Cappello, F., Kuban-Jankowska, A., Marino Gammazza, A., Knap, N., Wozniak, M., & Gorska-Ponikowska, M. (2018). Potential Health Benefits of Olive Oil and Plant Polyphenols. *International Journal of Molecular Sciences*, *19*(3), 686. https://doi.org/10.3390/ijms19030686

Greenberg, P. E., Fournier, A.-A., Sisitsky, T., Simes, M., Berman, R., Koenigsberg, S. H., & Kessler, R. C. (2021). The Economic Burden of Adults with Major Depressive Disorder in the United States (2010 and 2018). *PharmacoEconomics*, *39*(6), 653–665. https://doi.org/10.1007/s40273-021-01019-4

Haapakoski, R., Mathieu, J., Ebmeier, K. P., Alenius, H., & Kivimäki, M. (2015). Cumulative meta-analysis of interleukins 6 and 1β, tumour necrosis factor α and C-reactive protein in patients with major depressive disorder. *Brain, Behavior, and Immunity*, *49*, 206–215. https://doi.org/10.1016/j.bbi.2015.06.001

Hecht, E. M., Rabil, A., Martinez Steele, E., Abrams, G. A., Ware, D., Landy, D. C., & Hennekens, C. H. (2022). Cross-sectional examination of ultra-processed food consumption and adverse mental health symptoms. *Public Health Nutrition*, *25*(11), 3225–3234. https://doi.org/10.1017/S1368980022001586

Hemler, E. C., & Hu, F. B. (2019). Plant-Based Diets for Cardiovascular Disease Prevention: All Plant Foods Are Not Created Equal. *Current Atherosclerosis Reports*, *21*(5), 18. https://doi.org/10.1007/s11883-019-0779-5

Hu, D., Cheng, L., & Jiang, W. (2019). Sugar-sweetened beverages consumption and the risk of depression: A meta-analysis of observational studies. *Journal of Affective Disorders*, *245*, 348–355. https://doi.org/10.1016/j.jad.2018.11.015

Hu, F. B. (2002). Dietary pattern analysis: A new direction in nutritional epidemiology. *Current Opinion in Lipidology*, *13*(1), 3–9. https://doi.org/10.1097/00041433-200202000-00002

Iguacel, I., Huybrechts, I., Moreno, L. A., & Michels, N. (2021). Vegetarianism and veganism compared with mental health and cognitive outcomes: A systematic review and meta-analysis. *Nutrition Reviews*, *79*(4), 361–381. https://doi.org/10.1093/nutrit/nuaa030

Jacka, F. N., O'Neil, A., Opie, R., Itsiopoulos, C., Cotton, S., Mohebbi, M., Castle, D., Dash, S., Mihalopoulos, C., Chatterton, M. L., Brazionis, L., Dean, O. M., Hodge, A. M., & Berk, M. (2017). A randomised controlled trial of dietary improvement for adults with major depression (the "SMILES" trial). *BMC Medicine*, *15*(1), 23. https://doi.org/10.1186/s12916-017-0791-y

Jacka, F. N., Pasco, J. A., Mykletun, A., Williams, L. J., Hodge, A. M., O'Reilly, S. L., Nicholson, G. C., Kotowicz, M. A., & Berk, M. (2010). Association of Western and traditional diets with depression and anxiety in women. *The American Journal of Psychiatry*, *167*(3), 305–311. https://doi.org/10.1176/appi.ajp.2009.09060881

Jacobs, D. R., & Tapsell, L. C. (2013). Food synergy: The key to a healthy diet. *The Proceedings of the Nutrition Society*, *72*(2), 200–206. https://doi.org/10.1017/S0029665112003011

Jain, R., Larsuphrom, P., Degremont, A., Latunde-Dada, G. O., & Philippou, E. (2022). Association between vegetarian and vegan diets and depression: A systematic review. *Nutrition Bulletin*, *47*(1), 27–49. https://doi.org/10.1111/nbu.12540

Kahleova, H., Hrachovinova, T., Hill, M., & Pelikanova, T. (2013). Vegetarian diet in type 2 diabetes—Improvement in quality of life, mood and eating behaviour. *Diabetic Medicine: A Journal of the British Diabetic Association*, *30*(1), 127–129. https://doi.org/10.1111/dme.12032

Kandola, A., Ashdown-Franks, G., Hendrikse, J., Sabiston, C. M., & Stubbs, B. (2019). Physical activity and depression: Towards understanding the antidepressant mechanisms of physical activity. *Neuroscience and Biobehavioral Reviews*, *107*, 525–539. https://doi.org/10.1016/j.neubiorev.2019.09.040

Keyes, K. M., Kreski, N. T., & Patrick, M. E. (2024). Depressive Symptoms in Adolescence and Young Adulthood. *JAMA Network Open*, *7*(8), e2427748. https://doi.org/10.1001/jamanetworkopen.2024.27748

Keys, A., Menotti, A., Karvonen, M. J., Aravanis, C., Blackburn, H., Buzina, R., Djordjevic, B. S., Dontas, A. S., Fidanza, F., & Keys, M. H. (1986). The diet and 15-year death rate in the seven countries study. *American Journal of Epidemiology*, *124*(6), 903–915. https://doi.org/10.1093/oxfordjournals.aje.a114480

Kim, W. K., Shin, D., & Song, W. O. (2016). Are Dietary Patterns Associated with Depression in U.S. Adults? *Journal of Medicinal Food*, *19*(11), 1074–1084. https://doi.org/10.1089/jmf.2016.0043

Knüppel, A., Shipley, M. J., Llewellyn, C. H., & Brunner, E. J. (2017). Sugar intake from sweet food and beverages, common mental disorder and depression: Prospective findings from

the Whitehall II study. *Scientific Reports*, *7*(1), 6287. https://doi.org/10.1038/s41598-017-05649-7

Korczak, D. J., Westwell-Roper, C., & Sassi, R. (2023). Diagnosis and management of depression in adolescents. *CMAJ: Canadian Medical Association Journal = Journal de l'Association Medicale Canadienne*, *195*(21), E739–E746. https://doi.org/10.1503/cmaj.220966

Krogh, J., Nordentoft, M., Sterne, J. A. C., & Lawlor, D. A. (2011). The effect of exercise in clinically depressed adults: Systematic review and meta-analysis of randomized controlled trials. *The Journal of Clinical Psychiatry*, *72*(4), 529–538. https://doi.org/10.4088/JCP.08r04913blu

Lai, J. S., Hiles, S., Bisquera, A., Hure, A. J., McEvoy, M., & Attia, J. (2014). A systematic review and meta-analysis of dietary patterns and depression in community-dwelling adults. *The American Journal of Clinical Nutrition*, *99*(1), 181–197. https://doi.org/10.3945/ajcn.113.069880

Lane, M. M., Gamage, E., Travica, N., Dissanayaka, T., Ashtree, D. N., Gauci, S., Lotfaliany, M., O'Neil, A., Jacka, F. N., & Marx, W. (2022). Ultra-Processed Food Consumption and Mental Health: A Systematic Review and Meta-Analysis of Observational Studies. *Nutrients*, *14*(13), 2568. https://doi.org/10.3390/nu14132568

Larrieu, T., & Layé, S. (2018). Food for Mood: Relevance of Nutritional Omega-3 Fatty Acids for Depression and Anxiety. *Frontiers in Physiology*, *9*, 1047. https://doi.org/10.3389/fphys.2018.01047

Lassale, C., Batty, G. D., Baghdadli, A., Jacka, F., Sánchez-Villegas, A., Kivimäki, M., & Akbaraly, T. (2019). Healthy dietary indices and risk of depressive outcomes: A

systematic review and meta-analysis of observational studies. *Molecular Psychiatry*, *24*(7), 965–986. https://doi.org/10.1038/s41380-018-0237-8

Le Port, A., Gueguen, A., Kesse-Guyot, E., Melchior, M., Lemogne, C., Nabi, H., Goldberg, M., Zins, M., & Czernichow, S. (2012). Association between dietary patterns and depressive symptoms over time: A 10-year follow-up study of the GAZEL cohort. *PloS One*, *7*(12), e51593. https://doi.org/10.1371/journal.pone.0051593

Lee, M. F., Eather, R., & Best, T. (2021). Plant-based dietary quality and depressive symptoms in Australian vegans and vegetarians: A cross-sectional study. *BMJ Nutrition, Prevention & Health*, *4*(2), 479–486. https://doi.org/10.1136/bmjnph-2021-000332

Li, Y., Lv, M.-R., Wei, Y.-J., Sun, L., Zhang, J.-X., Zhang, H.-G., & Li, B. (2017). Dietary patterns and depression risk: A meta-analysis. *Psychiatry Research*, *253*, 373–382. https://doi.org/10.1016/j.psychres.2017.04.020

Liu, R. H. (2013). Health-promoting components of fruits and vegetables in the diet. *Advances in Nutrition*, *4*(3), 384S-92S. https://doi.org/10.3945/an.112.003517

Lopresti, A. L., Hood, S. D., & Drummond, P. D. (2013). A review of lifestyle factors that contribute to important pathways associated with major depression: Diet, sleep and exercise. *Journal of Affective Disorders*, *148*(1), 12–27. https://doi.org/10.1016/j.jad.2013.01.014

Ludwig, D. S., Hu, F. B., Tappy, L., & Brand-Miller, J. (2018). Dietary carbohydrates: Role of quality and quantity in chronic disease. *The BMJ*, *361*, k2340. https://doi.org/10.1136/bmj.k2340

Lyra E Silva, N. de M., Lam, M. P., Soares, C. N., Munoz, D. P., Milev, R., & De Felice, F. G. (2019). Insulin Resistance as a Shared Pathogenic Mechanism Between Depression and

Type 2 Diabetes. *Frontiers in Psychiatry*, *10*, 57. https://doi.org/10.3389/fpsyt.2019.00057

Madison, A., & Kiecolt-Glaser, J. K. (2019). Stress, depression, diet, and the gut microbiota: Human-bacteria interactions at the core of psychoneuroimmunology and nutrition. *Current Opinion in Behavioral Sciences*, *28*, 105–110. https://doi.org/10.1016/j.cobeha.2019.01.011

Malesza, I. J., Malesza, M., Walkowiak, J., Mussin, N., Walkowiak, D., Aringazina, R., Bartkowiak-Wieczorek, J., & Mądry, E. (2021). High-Fat, Western-Style Diet, Systemic Inflammation, and Gut Microbiota: A Narrative Review. *Cells*, *10*(11), 3164. https://doi.org/10.3390/cells10113164

Manach, C., Scalbert, A., Morand, C., Rémésy, C., & Jiménez, L. (2004). Polyphenols: Food sources and bioavailability. *The American Journal of Clinical Nutrition*, *79*(5), 727–747. https://doi.org/10.1093/ajcn/79.5.727

Mariotti, F., & Gardner, C. D. (2019). Dietary Protein and Amino Acids in Vegetarian Diets-A Review. *Nutrients*, *11*(11), 2661. https://doi.org/10.3390/nu11112661

Martínez-González, M. A., Gea, A., & Ruiz-Canela, M. (2019). The Mediterranean Diet and Cardiovascular Health. *Circulation Research*, *124*(5), 779–798. https://doi.org/10.1161/CIRCRESAHA.118.313348

Marx, W., Lane, M., Hockey, M., Aslam, H., Berk, M., Walder, K., Borsini, A., Firth, J., Pariante, C. M., Berding, K., Cryan, J. F., Clarke, G., Craig, J. M., Su, K.-P., Mischoulon, D., Gomez-Pinilla, F., Foster, J. A., Cani, P. D., Thuret, S., … Jacka, F. N. (2021). Diet and depression: Exploring the biological mechanisms of action. *Molecular Psychiatry*, *26*(1), 134–150. https://doi.org/10.1038/s41380-020-00925-x

Marx, W., Moseley, G., Berk, M., & Jacka, F. (2017). Nutritional psychiatry: The present state of the evidence. *The Proceedings of the Nutrition Society*, *76*(4), 427–436. https://doi.org/10.1017/S0029665117002026

Matta, J., Czernichow, S., Kesse-Guyot, E., Hoertel, N., Limosin, F., Goldberg, M., Zins, M., & Lemogne, C. (2018). Depressive Symptoms and Vegetarian Diets: Results from the Constances Cohort. *Nutrients*, *10*(11), 1695. https://doi.org/10.3390/nu10111695

McHugh, R. K., & Weiss, R. D. (2019). Alcohol Use Disorder and Depressive Disorders. *Alcohol Research : Current Reviews*, *40*(1), arcr.v40.1.01. https://doi.org/10.35946/arcr.v40.1.01

Medawar, E., Huhn, S., Villringer, A., & Veronica Witte, A. (2019). The effects of plant-based diets on the body and the brain: A systematic review. *Translational Psychiatry*, *9*(1), 226. https://doi.org/10.1038/s41398-019-0552-0

Melina, V., Craig, W., & Levin, S. (2016). Position of the Academy of Nutrition and Dietetics: Vegetarian Diets. *Journal of the Academy of Nutrition and Dietetics*, *116*(12), 1970–1980. https://doi.org/10.1016/j.jand.2016.09.025

Merlo, G., & Sugden, S. G. (2025). The Power of Lifestyle Psychiatry: A New Approach to Mental Health. *American Journal of Lifestyle Medicine*, *19*(7), 1034–1044. https://doi.org/10.1177/15598276251329915

Milaneschi, Y., Simmons, W. K., van Rossum, E. F. C., & Penninx, B. W. (2019). Depression and obesity: Evidence of shared biological mechanisms. *Molecular Psychiatry*, *24*(1), 18–33. https://doi.org/10.1038/s41380-018-0017-5

Miller, A. H., & Raison, C. L. (2016). The role of inflammation in depression: From evolutionary imperative to modern treatment target. *Nature Reviews. Immunology*, *16*(1), 22–34. https://doi.org/10.1038/nri.2015.5

Minihane, A. M., Vinoy, S., Russell, W. R., Baka, A., Roche, H. M., Tuohy, K. M., Teeling, J. L., Blaak, E. E., Fenech, M., Vauzour, D., McArdle, H. J., Kremer, B. H. A., Sterkman, L., Vafeiadou, K., Benedetti, M. M., Williams, C. M., & Calder, P. C. (2015). Low-grade inflammation, diet composition and health: Current research evidence and its translation. *The British Journal of Nutrition*, *114*(7), 999–1012. https://doi.org/10.1017/S0007114515002093

Molendijk, M., Molero, P., Ortuño Sánchez-Pedreño, F., Van der Does, W., & Angel Martínez-González, M. (2018). Diet quality and depression risk: A systematic review and dose-response meta-analysis of prospective studies. *Journal of Affective Disorders*, *226*, 346–354. https://doi.org/10.1016/j.jad.2017.09.022

Monteiro, C. A., Cannon, G., Levy, R. B., Moubarac, J.-C., Louzada, M. L., Rauber, F., Khandpur, N., Cediel, G., Neri, D., Martinez-Steele, E., Baraldi, L. G., & Jaime, P. C. (2019). Ultra-processed foods: What they are and how to identify them. *Public Health Nutrition*, *22*(5), 936–941. https://doi.org/10.1017/S1368980018003762

Moubarac, J.-C., Batal, M., Martins, A. P. B., Claro, R., Levy, R. B., Cannon, G., & Monteiro, C. (2014). Processed and ultra-processed food products: Consumption trends in Canada from 1938 to 2011. *Canadian Journal of Dietetic Practice and Research: A Publication of Dietitians of Canada = Revue Canadienne De La Pratique Et De La Recherche En Dietetique: Une Publication Des Dietetistes Du Canada*, *75*(1), 15–21. https://doi.org/10.3148/75.1.2014.15

Myles, I. A. (2014). Fast food fever: Reviewing the impacts of the Western diet on immunity. *Nutrition Journal*, *13*, 61. https://doi.org/10.1186/1475-2891-13-61

Neufingerl, N., & Eilander, A. (2021). Nutrient Intake and Status in Adults Consuming Plant-Based Diets Compared to Meat-Eaters: A Systematic Review. *Nutrients*, *14*(1), 29. https://doi.org/10.3390/nu14010029

Newby, P. K., & Tucker, K. L. (2004). Empirically derived eating patterns using factor or cluster analysis: A review. *Nutrition Reviews*, *62*(5), 177–203. https://doi.org/10.1301/nr.2004.may.177-203

Nucci, D., Fatigoni, C., Amerio, A., Odone, A., & Gianfredi, V. (2020). Red and Processed Meat Consumption and Risk of Depression: A Systematic Review and Meta-Analysis. *International Journal of Environmental Research and Public Health*, *17*(18), 6686. https://doi.org/10.3390/ijerph17186686

Nutt, D., Wilson, S., & Paterson, L. (2008). Sleep disorders as core symptoms of depression. *Dialogues in Clinical Neuroscience*, *10*(3), 329–336. https://doi.org/10.31887/DCNS.2008.10.3/dnutt

Ocklenburg, S., & Borawski, J. (2021). Vegetarian diet and depression scores: A meta-analysis. *Journal of Affective Disorders*, *294*, 813–815. https://doi.org/10.1016/j.jad.2021.07.098

Oddy, W. H., Robinson, M., Ambrosini, G. L., O'Sullivan, T. A., de Klerk, N. H., Beilin, L. J., Silburn, S. R., Zubrick, S. R., & Stanley, F. J. (2009). The association between dietary patterns and mental health in early adolescence. *Preventive Medicine*, *49*(1), 39–44. https://doi.org/10.1016/j.ypmed.2009.05.009

O'Leary, F., & Samman, S. (2010). Vitamin B12 in health and disease. *Nutrients*, *2*(3), 299–316. https://doi.org/10.3390/nu2030299

Opie, R. S., O'Neil, A., Jacka, F. N., Pizzinga, J., & Itsiopoulos, C. (2018). A modified Mediterranean dietary intervention for adults with major depression: Dietary protocol and feasibility data from the SMILES trial. *Nutritional Neuroscience*, *21*(7), 487–501. https://doi.org/10.1080/1028415X.2017.1312841

Osimo, E. F., Pillinger, T., Rodriguez, I. M., Khandaker, G. M., Pariante, C. M., & Howes, O. D. (2020). Inflammatory markers in depression: A meta-analysis of mean differences and variability in 5,166 patients and 5,083 controls. *Brain, Behavior, and Immunity*, *87*, 901–909. https://doi.org/10.1016/j.bbi.2020.02.010

Pariante, C. M., & Lightman, S. L. (2008). The HPA axis in major depression: Classical theories and new developments. *Trends in Neurosciences*, *31*(9), 464–468. https://doi.org/10.1016/j.tins.2008.06.006

Parker, H. W., & Vadiveloo, M. K. (2019). Diet quality of vegetarian diets compared with nonvegetarian diets: A systematic review. *Nutrition Reviews*, *77*(3), 144–160. https://doi.org/10.1093/nutrit/nuy067

Parletta, N., Zarnowiecki, D., Cho, J., Wilson, A., Bogomolova, S., Villani, A., Itsiopoulos, C., Niyonsenga, T., Blunden, S., Meyer, B., Segal, L., Baune, B. T., & O'Dea, K. (2019). A Mediterranean-style dietary intervention supplemented with fish oil improves diet quality and mental health in people with depression: A randomized controlled trial (HELFIMED). *Nutritional Neuroscience*, *22*(7), 474–487. https://doi.org/10.1080/1028415X.2017.1411320

Penninx, B. W. J. H., & Lange, S. M. M. (2018). Metabolic syndrome in psychiatric patients: Overview, mechanisms, and implications. *Dialogues in Clinical Neuroscience*, *20*(1), 63–73. https://doi.org/10.31887/DCNS.2018.20.1/bpenninx

Pittenger, C., & Duman, R. S. (2008). Stress, depression, and neuroplasticity: A convergence of mechanisms. *Neuropsychopharmacology: Official Publication of the American College of Neuropsychopharmacology*, *33*(1), 88–109. https://doi.org/10.1038/sj.npp.1301574

Popkin, B. M., Adair, L. S., & Ng, S. W. (2012). Global nutrition transition and the pandemic of obesity in developing countries. *Nutrition Reviews*, *70*(1), 3–21. https://doi.org/10.1111/j.1753-4887.2011.00456.x

Quirk, S. E., Williams, L. J., O'Neil, A., Pasco, J. A., Jacka, F. N., Housden, S., Berk, M., & Brennan, S. L. (2013). The association between diet quality, dietary patterns and depression in adults: A systematic review. *BMC Psychiatry*, *13*, 175. https://doi.org/10.1186/1471-244X-13-175

Rădulescu, I., Drăgoi, A. M., Trifu, S. C., & Cristea, M. B. (2021). Neuroplasticity and depression: Rewiring the brain's networks through pharmacological therapy (Review). *Experimental and Therapeutic Medicine*, *22*(4), 1131. https://doi.org/10.3892/etm.2021.10565

Remes, O., Mendes, J. F., & Templeton, P. (2021). Biological, Psychological, and Social Determinants of Depression: A Review of Recent Literature. *Brain Sciences*, *11*(12), 1633. https://doi.org/10.3390/brainsci11121633

Reynolds, A., Mann, J., Cummings, J., Winter, N., Mete, E., & Te Morenga, L. (2019). Carbohydrate quality and human health: A series of systematic reviews and meta-analyses. *Lancet*, *393*(10170), 434–445. https://doi.org/10.1016/S0140-6736(18)31809-9

Rimer, J., Dwan, K., Lawlor, D. A., Greig, C. A., McMurdo, M., Morley, W., & Mead, G. E. (2012). Exercise for depression. *The Cochrane Database of Systematic Reviews*, (7), CD004366. https://doi.org/10.1002/14651858.CD004366.pub5

Rizzo, N. S., Jaceldo-Siegl, K., Sabate, J., & Fraser, G. E. (2013). Nutrient profiles of vegetarian and nonvegetarian dietary patterns. *Journal of the Academy of Nutrition and Dietetics*, *113*(12), 1610–1619. https://doi.org/10.1016/j.jand.2013.06.349

Romagnolo, D. F., & Selmin, O. I. (2017). Mediterranean Diet and Prevention of Chronic Diseases. *Nutrition Today*, *52*(5), 208–222. https://doi.org/10.1097/NT.0000000000000228

Rosenfeld, D. L. (2018). The psychology of vegetarianism: Recent advances and future directions. *Appetite*, *131*, 125–138. https://doi.org/10.1016/j.appet.2018.09.011

Samuthpongtorn, C., Nguyen, L. H., Okereke, O. I., Wang, D. D., Song, M., Chan, A. T., & Mehta, R. S. (2023). Consumption of Ultraprocessed Food and Risk of Depression. *JAMA Network Open*, *6*(9), e2334770. https://doi.org/10.1001/jamanetworkopen.2023.34770

Sánchez-Villegas, A., Delgado-Rodríguez, M., Alonso, A., Schlatter, J., Lahortiga, F., Serra Majem, L., & Martínez-González, M. A. (2009). Association of the Mediterranean dietary pattern with the incidence of depression: The Seguimiento Universidad de Navarra/University of Navarra follow-up (SUN) cohort. *Archives of General Psychiatry*, *66*(10), 1090–1098. https://doi.org/10.1001/archgenpsychiatry.2009.129

Sánchez-Villegas, A., Martínez-González, M. A., Estruch, R., Salas-Salvadó, J., Corella, D., Covas, M. I., Arós, F., Romaguera, D., Gómez-Gracia, E., Lapetra, J., Pintó, X., Martínez, J. A., Lamuela-Raventós, R. M., Ros, E., Gea, A., Wärnberg, J., & Serra-Majem, L. (2013). Mediterranean dietary pattern and depression: The PREDIMED randomized trial. *BMC Medicine*, *11*, 208. https://doi.org/10.1186/1741-7015-11-208

Sánchez-Villegas, A., Toledo, E., de Irala, J., Ruiz-Canela, M., Pla-Vidal, J., & Martínez-González, M. A. (2012). Fast-food and commercial baked goods consumption and the risk of depression. *Public Health Nutrition*, *15*(3), 424–432. https://doi.org/10.1017/S1368980011001856

Sarris, J., Logan, A. C., Akbaraly, T. N., Amminger, G. P., Balanzá-Martínez, V., Freeman, M. P., Hibbeln, J., Matsuoka, Y., Mischoulon, D., Mizoue, T., Nanri, A., Nishi, D., Ramsey, D., Rucklidge, J. J., Sanchez-Villegas, A., Scholey, A., Su, K.-P., Jacka, F. N., & International Society for Nutritional Psychiatry Research. (2015). Nutritional medicine as mainstream in psychiatry. *The Lancet. Psychiatry*, *2*(3), 271–274. https://doi.org/10.1016/S2215-0366(14)00051-0

Satija, A., Bhupathiraju, S. N., Rimm, E. B., Spiegelman, D., Chiuve, S. E., Borgi, L., Willett, W. C., Manson, J. E., Sun, Q., & Hu, F. B. (2016). Plant-Based Dietary Patterns and Incidence of Type 2 Diabetes in US Men and Women: Results from Three Prospective Cohort Studies. *PLoS Medicine*, *13*(6), e1002039. https://doi.org/10.1371/journal.pmed.1002039

Satija, A., Bhupathiraju, S. N., Spiegelman, D., Chiuve, S. E., Manson, J. E., Willett, W., Rexrode, K. M., Rimm, E. B., & Hu, F. B. (2017). Healthful and Unhealthful Plant-Based Diets and the Risk of Coronary Heart Disease in U.S. Adults. *Journal of the American College of Cardiology*, *70*(4), 411–422. https://doi.org/10.1016/j.jacc.2017.05.047

Saunders, A. V., Davis, B. C., & Garg, M. L. (2013). Omega-3 polyunsaturated fatty acids and vegetarian diets. *The Medical Journal of Australia*, *199*(S4), S22-26. https://doi.org/10.5694/mja11.11507

Schuch, F. B., Vancampfort, D., Firth, J., Rosenbaum, S., Ward, P. B., Silva, E. S., Hallgren, M., Ponce De Leon, A., Dunn, A. L., Deslandes, A. C., Fleck, M. P., Carvalho, A. F., & Stubbs, B. (2018). Physical Activity and Incident Depression: A Meta-Analysis of Prospective Cohort Studies. *The American Journal of Psychiatry*, *175*(7), 631–648. https://doi.org/10.1176/appi.ajp.2018.17111194

Schüpbach, R., Wegmüller, R., Berguerand, C., Bui, M., & Herter-Aeberli, I. (2017). Micronutrient status and intake in omnivores, vegetarians and vegans in Switzerland. *European Journal of Nutrition*, *56*(1), 283–293. https://doi.org/10.1007/s00394-015-1079-7

Serra-Majem, L., Tomaino, L., Dernini, S., Berry, E. M., Lairon, D., Ngo de la Cruz, J., Bach-Faig, A., Donini, L. M., Medina, F.-X., Belahsen, R., Piscopo, S., Capone, R., Aranceta-Bartrina, J., La Vecchia, C., & Trichopoulou, A. (2020). Updating the Mediterranean Diet Pyramid towards Sustainability: Focus on Environmental Concerns. *International Journal of Environmental Research and Public Health*, *17*(23), 8758. https://doi.org/10.3390/ijerph17238758

Shim, J.-S., Oh, K., & Kim, H. C. (2014). Dietary assessment methods in epidemiologic studies. *Epidemiology and Health*, *36*, e2014009. https://doi.org/10.4178/epih/e2014009

Shivappa, N., Steck, S. E., Hurley, T. G., Hussey, J. R., & Hébert, J. R. (2014). Designing and developing a literature-derived, population-based dietary inflammatory index. *Public Health Nutrition*, *17*(8), 1689–1696. https://doi.org/10.1017/S1368980013002115

Simopoulos, A. P. (2016). An Increase in the Omega-6/Omega-3 Fatty Acid Ratio Increases the Risk for Obesity. *Nutrients*, *8*(3), 128. https://doi.org/10.3390/nu8030128

Skarupski, K. A., Tangney, C. C., Li, H., Evans, D. A., & Morris, M. C. (2013). Mediterranean diet and depressive symptoms among older adults over time. *The Journal of Nutrition, Health & Aging*, *17*(5), 441–445. https://doi.org/10.1007/s12603-012-0437-x

Slavin, J. (2013). Fiber and prebiotics: Mechanisms and health benefits. *Nutrients*, *5*(4), 1417–1435. https://doi.org/10.3390/nu5041417

Sofi, F., Macchi, C., Abbate, R., Gensini, G. F., & Casini, A. (2014). Mediterranean diet and health status: An updated meta-analysis and a proposal for a literature-based adherence score. *Public Health Nutrition*, *17*(12), 2769–2782. https://doi.org/10.1017/S1368980013003169

Statovci, D., Aguilera, M., MacSharry, J., & Melgar, S. (2017). The Impact of Western Diet and Nutrients on the Microbiota and Immune Response at Mucosal Interfaces. *Frontiers in Immunology*, *8*, 838. https://doi.org/10.3389/fimmu.2017.00838

Stephen, A. M., Champ, M. M.-J., Cloran, S. J., Fleith, M., van Lieshout, L., Mejborn, H., & Burley, V. J. (2017). Dietary fibre in Europe: Current state of knowledge on definitions, sources, recommendations, intakes and relationships to health. *Nutrition Research Reviews*, *30*(2), 149–190. https://doi.org/10.1017/S095442241700004X

Storz, M. A., & Ronco, A. L. (2023). Adherence to a Vegetarian Diet is not Associated With Depression: Results From the National Health and Nutrition Examination Surveys. *Psychiatry Investigation*, *20*(4), 315–324. https://doi.org/10.30773/pi.2022.0251

Thapar, A., Collishaw, S., Pine, D. S., & Thapar, A. K. (2012). Depression in adolescence. *Lancet*, *379*(9820), 1056–1067. https://doi.org/10.1016/S0140-6736(11)60871-4

Tomova, A., Bukovsky, I., Rembert, E., Yonas, W., Alwarith, J., Barnard, N. D., & Kahleova, H. (2019). The Effects of Vegetarian and Vegan Diets on Gut Microbiota. *Frontiers in Nutrition*, *6*, 47. https://doi.org/10.3389/fnut.2019.00047

Tosti, V., Bertozzi, B., & Fontana, L. (2018). Health Benefits of the Mediterranean Diet: Metabolic and Molecular Mechanisms. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *73*(3), 318–326. https://doi.org/10.1093/gerona/glx227

Trichopoulou, A., Costacou, T., Bamia, C., & Trichopoulos, D. (2003). Adherence to a Mediterranean diet and survival in a Greek population. *The New England Journal of Medicine*, *348*(26), 2599–2608. https://doi.org/10.1056/NEJMoa025039

Tuso, P. J., Ismail, M. H., Ha, B. P., & Bartolotto, C. (2013). Nutritional Update for Physicians: Plant-Based Diets. *The Permanente Journal*, *17*(2), 61–66. https://doi.org/10.7812/TPP/12-085

Ventriglio, A., Sancassiani, F., Contu, M. P., Latorre, M., Di Salvatore, M., Fornaro, M., & Bhugra, D. (2020). Mediterranean Diet and its Benefits on Health and Mental Health: A Literature Review. *Clinical Practice and Epidemiology in Mental Health: CP & EMH*, *16*(Suppl-1), 156–164. https://doi.org/10.2174/1745017902016010156

Wang, J., Zhou, Y., Chen, K., Jing, Y., He, J., Sun, H., & Hu, X. (2019). Dietary inflammatory index and depression: A meta-analysis. *Public Health Nutrition*, *22*(4), 654–660. https://doi.org/10.1017/S1368980018002628

Wang, T., Masedunskas, A., Willett, W. C., & Fontana, L. (2023). Vegetarian and vegan diets: Benefits and drawbacks. *European Heart Journal*, *44*(36), 3423–3439. https://doi.org/10.1093/eurheartj/ehad436

Wang, Y., Zhao, R., Wang, B., Zhao, C., Zhu, B., & Tian, X. (2022). The Dose-Response Associations of Sugar-Sweetened Beverage Intake with the Risk of Stroke, Depression, Cancer, and Cause-Specific Mortality: A Systematic Review and Meta-Analysis of Prospective Studies. *Nutrients*, *14*(4), 777. https://doi.org/10.3390/nu14040777

Watanabe, F., Yabuta, Y., Bito, T., & Teng, F. (2014). Vitamin B12-Containing Plant Food Sources for Vegetarians. *Nutrients*, *6*(5), 1861–1873. https://doi.org/10.3390/nu6051861

Weng, T.-T., Hao, J.-H., Qian, Q.-W., Cao, H., Fu, J.-L., Sun, Y., Huang, L., & Tao, F.-B. (2012). Is there any relationship between dietary patterns and depression and anxiety in Chinese adolescents? *Public Health Nutrition*, *15*(4), 673–682. https://doi.org/10.1017/S1368980011003077

Widmer, R. J., Flammer, A. J., Lerman, L. O., & Lerman, A. (2015). The Mediterranean diet, its components, and cardiovascular disease. *The American Journal of Medicine*, *128*(3), 229–238. https://doi.org/10.1016/j.amjmed.2014.10.014

Wong, M.-W., Yi, C.-H., Liu, T.-T., Lei, W.-Y., Hung, J.-S., Lin, C.-L., Lin, S.-Z., & Chen, C.-L. (2018). Impact of vegan diets on gut microbiota: An update on the clinical implications. *Tzu-Chi Medical Journal*, *30*(4), 200–203. https://doi.org/10.4103/tcmj.tcmj_21_18

Zamora-Ros, R., Knaze, V., Rothwell, J. A., Hémon, B., Moskal, A., Overvad, K., Tjønneland, A., Kyrø, C., Fagherazzi, G., Boutron-Ruault, M.-C., Touillaud, M., Katzke, V., Kühn, T., Boeing, H., Förster, J., Trichopoulou, A., Valanou, E., Peppa, E., Palli, D., … Scalbert, A. (2016). Dietary polyphenol intake in Europe: The European Prospective Investigation into Cancer and Nutrition (EPIC) study. *European Journal of Nutrition*, *55*(4), 1359–1375. https://doi.org/10.1007/s00394-015-0950-x

Zhai, L., Zhang, H., & Zhang, D. (2015). SLEEP DURATION AND DEPRESSION AMONG ADULTS: A META-ANALYSIS OF PROSPECTIVE STUDIES. *Depression and Anxiety*, *32*(9), 664–670. https://doi.org/10.1002/da.22386

Zhang, H., Li, M., Mo, L., Luo, J., Shen, Q., & Quan, W. (2023). Association between Western Dietary Patterns, Typical Food Groups, and Behavioral Health Disorders: An Updated Systematic Review and Meta-Analysis of Observational Studies. *Nutrients*, *16*(1), 125. https://doi.org/10.3390/nu16010125

Zhang, L., Chen, S., Xu, L., Tang, S., Huang, C., Zhou, J., Liu, C.-S., Wang, S., Cong, Y., Li, T., Chen, L., Zhang, W., & Rong, S. (2025). Association between plant-based diets and depressive symptoms among Chinese middle-aged and older adults. *NPJ Science of Food*, *9*(1), 42. https://doi.org/10.1038/s41538-025-00399-7

Zhou, W., Zhang, H., He, J., & Shen, J. (2025). Association Between Plant-Based Dietary Patterns and the Long-Term Trajectory of Depressive Symptoms: A 10-Year Longitudinal Study. *Journal of the American Medical Directors Association*, *26*(8), 105712. https://doi.org/10.1016/j.jamda.2025.105712

Zhu, F., Tu, H., & Chen, T. (2022). The Microbiota–Gut–Brain Axis in Depression: The Potential Pathophysiological Mechanisms and Microbiota Combined Antidepression Effect. *Nutrients*, *14*(10), 2081. https://doi.org/10.3390/nu14102081

Zinöcker, M. K., & Lindseth, I. A. (2018). The Western Diet-Microbiome-Host Interaction and Its Role in Metabolic Disease. *Nutrients*, *10*(3), 365. https://doi.org/10.3390/nu10030365